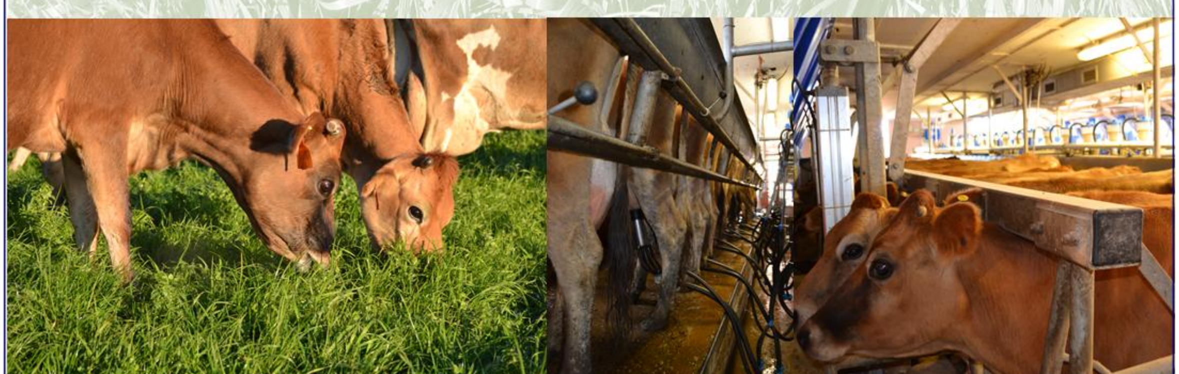
INLIGTINGSDAG

Volhoubare melkproduksie vanaf aangeplante weidings

2012

INFORMATION DAY

Sustainable milk production from planted pastures



Western Cape Government

Agriculture

Outeniqua Research Farm

Institutes for Plant and Animal Production

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INLIGTINGSDAG-PROGRAM

Outeniqua Navorsingsplaas, George

Volhoubare melkproduksie vanaf aangeplante weidings

30 Oktober 2012

Voorsitter	**Dr Ilse Trautmann**
08:00-09:00	***Registrasie*** (R50). Besigtiging van wetenskaplike- en nywerheidsuitstallings
09:00-09:10	Skriflesing en gebed
09:10-09:30	Openingstoespraak (Wes-Kaapse Minister van Landbou en Landelike Ontwikkeling) ***Minister Gerrit van Rensburg***
09:30-09:45	Grondgehalte aanwysers en die invloed daarvan op grondgesondheid ***Pieter Swanepoel***
09:45-10:00	Subtropiese grasse en somervoergewasse as alternatiewe weiding ***Dalena Lombard***
10:00-10:20	Kultivarevaluasie: produksiepotensiaal van een- en meerjarige grasse en peulgewasse ***Janke van der Colf***
10:20-11:00	***Tee***
11:00 -11:20	Invloed van saaidatum op die produksiepotensiaal van eenjarige raaigrasse ***Dr Philip Botha***
11:20-11:35	Oorbrugging van weidingstekorte met hoë vesel kragvoer gedurende die winter ***Lobke Steyn***
11:35-11:50	"Palm kernel expeller" as byvoeding vir melkbeeste ***Josef van Wyngaard***
11:50-12:10	Verhoog wins deur minder vervangingsverse groot te maak ***Prof Robin Meeske***
12:10-12:20	Vrae en opsomming
12:20-12:30	Oorhandiging: Peter Edwards toekenning ***Annelene Swanepoel***
12:30-14:00	Besoek aan navorsingsprojekte: Kultivarevaluasie, lusern/gras oorsaaipraktyke, kikoejoe/swenkgras/kropaargras oorsaaipraktyke, evaluasie van buffers as aanvulling aan koeie op weiding
14:00	***Middagete*** - Namiddag: Skouing van wetenskaplike en industriële uitstallings

INFORMATION DAY PROGRAMME

Outeniqua Research Farm, George

Sustainable milk production from planted pastures

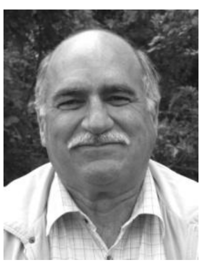
30 October 2012

Chairperson	**Dr Ilse Trautmann**
08:00-09:00	***Registration*** (R50). Viewing of scientific and industrial exhibitions
09:00-09:10	Scripture and prayer
09:10-09:30	Opening address (Western Cape Minister for Agriculture and Rural Development) – ***Minister Gerrit van Rensburg***
09:30-09:45	Soil quality indicators and their influence on soil health
	Pieter Swanepoel
09:45-10:00	Subtropical grasses and summer forage crops as alternative pasture
	Dalena Lombard
10:00-10:20	Cultivar evaluation: Production potential of annual and perennial grasses and legumes ***Janke van der Colf***
10:20-11:00	***Tea***
11:00 -11:20	The influence of planting date on the production potential of annual ryegrass
	Dr Philip Botha
11:20-11:35	High fibre concentrate fed to dairy cows to overcome pasture shortages during winter ***Lobke Steyn***
11:35-11:50	Palm kernel expeller as supplement for dairy cows
	Josef van Wyngaard
11:50-12:10	Rearing less replacement heifers to increase profit
	Prof Robin Meeske
12:10-12:20	Questions and summary
12:20-12:30	Handing over of Peter Edwards Award
	Annelene Swanepoel
12:30-14:00	Visit research projects
	Cultivar evaluation, Lucerne/grass over-sowing practices, kikuyu/fescue/cocksfoot over- sow trial, evaluation of buffers as supplement to cows on pasture
14:00	***Lunch*** - Afternoon: Viewing of scientific and industrial exhibitions

SPREKERS BY DIE INLIGTINGSDAG

Minister Gerrit van Rensburg
Wes-Kaapse Minister van Landbou en Landelike Ontwikkeling

Dr. Ilse Trautmann
Direkteur : Navorsing en Tegnologie Ontwikkelingsdienste
Wes-Kaapse Departement van Landbou
ilset@elsenburg.com



Dr. Philip Botha
Spesialis Landbouwetenskaplike
Instituut vir Plantproduksie, Outeniqua Navorsingsplaas
Wes-Kaap Departement van Landbou
Tel: 044-8033712, Sel no: 0836411395
philipb@elsenburg.com

Prof. Robin Meeske
Spesialis Landbouwetenskaplike
Instituut vir Diereproduksie, Outeniqua Navorsingsplaas
Wes-Kaapse Departement van Landbou
Tel: 044-8033708, Sel no: 0829084110
robinm@elsenburg.com

Mnr. Pieter Swanepoel
Landbouwetenskaplike: Grondgehalte en weidings
Instituut vir Plantproduksie, Outeniqua Navorsingsplaas
Wes-Kaapse Departement van Landbou
Tel: 044-8033726; Sel no 0721129155
pieters@elsenburg.com

Me. Janke van der Colf
Landbouwetenskaplike: Weidingstelsels
Instituut vir Plantproduksie, Outeniqua Navorsingsplaas
Wes-Kaapse Departement van Landbou
Tel: 044-8033718; Sel no: 0827749164
pieters@elsenburg.com

Me. Dalena Lombard
Landbounavorsingstegnikus
Instituut vir Plantproduksie, Outeniqua Navorsingsplaas
Wes-Kaapse Departement van Landbou
Tel: 044-8033714
dalenal@elsenburg.com

Mnr. Josef van Wyngaard
MSc(Agric) Student, Universiteit van Pretoria
Instituut vir Diereproduksie, Outeniqua Navorsingsplaas
Wes-Kaapse Departement van Landbou
Tel: 044-8033735
josefvw@elsenburg.com

Me. Lobke Steyn
MSc(Agric) Student, Universiteit van Stellenbosch
Instituut vir Diereproduksie, Outeniqua Navorsingsplaas
Wes-Kaapse Departement van Landbou
Tel: 044-8033735
lobkes@elsenburg.com

VOORWOORD

Die Outeniqua inligtingsdag van die Departement van Landbou Wes-Kaap het nou al 'n jaarlikse instelling geword en het sy plek op die tegnologie oordrag kalender van die Suid-Kaap stewig gevestig. Navorsing is en sal altyd een van die sleutelprioriteite van ons Departement bly, daar voorpunttegnologie ontwikkeling en oordrag ons boere sal verseker van hulle wenplek in die internasionale en nasionale markplek.

Dit is vir ons navorsingspan van kritiese belang om die jongste navorsingsinligting deur die plaashek te neem waar dit vir u as boer meer volhoubaar en ekonomies kan laat boer. Verder wil ons ook weer vir u met hierdie inligtingsdag verseker dat ons toegewyde en goedopgeleide navorsingspan, gerugsteun deur uitgebreide navorsings-infrastruktuur, die suiwelbedryf in die Wes- en Suid-Kaap met 'n grootste poging ondersteun.

Ons weiding- en suiwelnavorsingspan is van die bestes in die land en soos die nuwe slagspreuk van die Provinsiale Regering van die Wes-Kaap dit duidelik stel – ***"better together"*** of ***"beter tesame"*** – kan ons en u as boere saam die pad na die soeke vir oplossings, winsgewendheid en volhoubaarheid stap.

Skuur gerus vandag skouer met ons kenners en mede-boere en neem die vrymoedigheid om ook na die inligtingsdag ons navorsingsplaas te besoek – dit is **u** navorsingsplaas waar **u** navorsing gedoen word en u insette is vir ons van kardinale belang om ons navorsingspoging gefokus te hou.

Dr. Ilse Trautmann

HOOFDIREKTEUR: NAVORSING EN TEGNOLOGIE ONTWIKKELINGSDIENSTE, DEPARTEMENT LANDBOU WES-KAAP

SOIL QUALITY INDICATORS AND THEIR INFLUENCE ON SOIL HEALTH

PA Swanepoel[1] & PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction: What is soil quality and soil health?

There has been much controversy about the definition and perceptions of soil quality (Doran and Parkin 1994, Doran et al. 1996, Abbott and Murphy 2003, Sojka et al. 2003). Historically, soil quality has been linked to productivity and crop yield (Jaenicke and Lengnick 1999) and emphasis fell on the impact of management and not necessarily on soil quality *per se* (Karlen et al. 2003). Agricultural soil has generally been assessed visually, classifying it as good, poor, productive or degraded soil (Doran et al. 1996, Brady and Weil 2002). In order to manage, maintain or enhance soil to an acceptable condition to be used by future generations (Doran et al. 1996), the importance of soil quality should be stressed. Quality is a term used to describe the degree or extent of excellence of an entity. Entities such as water, air, food and forage have specific standards indicating the quality thereof (Doran and Parkin 1994). Soil quality has been defined as follow:

"The fitness of a specific kind of soil, to function within its capacity and within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (Karlen et al. 1997, Arshad and Martin 2002)

or

"How the soil is functioning" (Karlen et al. 2002).

Soil is seen as a living entity, and therefore the term soil health can be used to describe the state or condition of the soil. Soil health is a term used more frequently as a laymen term, and often synonymously to soil quality (Karlen et al. 1997, Nielsen and Winding 2002, Bone et al. 2010). Farmers favour the term soil health descriptively referring to the soil as healthy or unhealthy, portraying the soil as a living and dynamic entity, whose functions are mediated by a complex interrelationship of biota that require management and conservation (Karlen et al. 1997, Doran and Zeiss 2000). Researchers, conversely, use analytical measurements to connect soil function and specific soil properties and therefore prefer the term soil quality (Karlen et al. 1997).

Many processes are involved in soil quality. One can divide these soil processes into three soil quality domains or components namely chemical, physical and biological processes (Figure 1). The level of soil health results from the soil's characteristics and the interactions that occur between these three components (Idowu et al. 2008).

The inherent soil characteristics are those properties of soil which are a function of the parent rock and geology of the region and therefore, essentially static (Carter et al. 1997). Those characteristics will show little or no change due to management, external influences or land use, and provides an inert capacity for crop growth (Carter 1996). It is therefore important for farmers to know their soil's behaviour and consequently only select crops which will be suited best to the specific soil form.

Many other soil characteristics are dynamic. The soil is a living system as such there are many properties of soil that can be modified by management practices. Those include amongst others; addition of fertiliser, irrigation and cultivation.

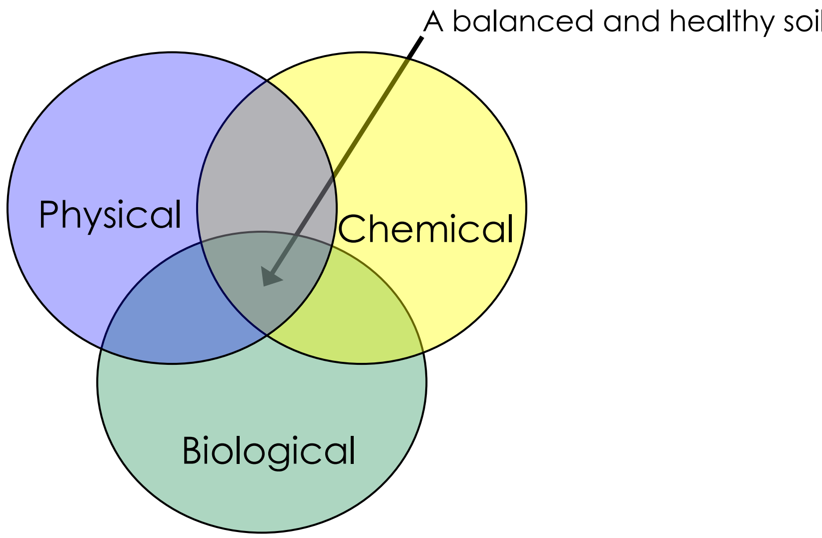


Figure 1: A schematic illustration of the integration of chemical, biological and physical components of soil health to ensure a balanced and healthy soil (Idowu et al. 2008).

A balance between the chemical, physical and biological components contribute to maintaining soil health. Evaluation of soil quality and health therefore requires indicators of all these components.

Which soil quality indicators should be selected?

An indicator of soil quality is a parameter that corresponds to properties of the environment and can provide information beyond that of the measured parameter alone (Nielsen and Winding 2002). These indicators provide information on the normality of soil functioning (Nielsen and Winding 2002). Indicator values should be based on data for indicators which infer information about proper functioning of the soil at full potential (Lal 1998). A soil quality indicator should be selected on the basis of ease of measurement, reproducibility and sensitivity towards key processes that have an effect on soil health. Each indicator should represent a slightly different aspect of soil health and provide a broad enough spectrum to give the farmer an overview of the state of his soils. On this basis a list of 53 indicators are currently being investigated on the Outeniqua Research Farm to provide insight on the most suitable group of indicators for pasture based dairy systems in the southern Cape region of South Africa. The objective of this portion of the study was to evaluate the effects that conversion from a natural, virgin soil to a no-till pasture system had on soil quality indicators.

Materials and methods

The experimental sites were located on the Outeniqua Research Farm near George, South Africa. Two sites characterized by a high potential podzolic soil. The soil form was classified as a cumulic-hydromorphic (Witfontein) form (Fey et al. 2010, Soil Classification Working Group 1991). The land use and species composition differed between sites. Site 1 consisted of a kikuyu based pasture established at least 19 years ago and managed as a minimum-till pasture. Annual Westerwold ryegrass was incorporated into the kikuyu base once a year during autumn. This was achieved by minimum-till methods using a mulcher and an Aitchison planter (Botha 2003, Van der Colf et al. 2011). The soil's fertility status was determined annually by soil analyses to maintain the nutrient status at the required levels for a kikuyu-ryegrass pasture. Nitrogen was applied at an approximate rate of 420 kg N ha^{-1} $year^{-1}$ in equal increments after every graze. The pasture was under permanent irrigation and the soil moisture content was maintained by means of tensiometers. A rising plate meter was used to determine the amount of herbage before every grazing by measuring height and compressibility of the pasture. Site 2 had never been cultivated and consisted of an undivided area that has been preserved as virgin soil and natural rangeland. The vegetation type was *Renosterveld* and the main plant species present were typical *fynbos* species occurring naturally in the area. Animals were not allowed to graze this area.

The soil sampling procedure was consistent among all parameters measured, except for *in situ* measurements (bulk density, penetration resistance and infiltration rate). Representative samples were taken on each plot. Soil samples consisted of 20 subsamples, sectioned into depth increments of 0 – 100 mm, 100 – 200 mm and 200 – 300 mm. Cores were collected equidistantly on two crossed transects within the plot and the outer 2 m of the plots were avoided to eliminate any side-effects. Soil samples were taken on 17 – 18 October 2011. The following parameters were evaluated within each of the three soil quality components:

Chemical indicators:

- Micro- and macro-nutrients: total N, extractable P, exchangeable Ca, Mg, K and Na, extractable Cu, Mn and Zn.
- pH (water) and pH (KCl)
- Cation exchange capacity (CEC)
- Resistance

Physical indicators:

- Texture
- Bulk density
- Penetration resistance (compaction)
- Water stable aggregate %

Biological indicators:

- Microbial biomass-C
- Potentially mineralizable Nitrogen (PMN)
- C:N ratio
- Loss-on-ignition (LOI)
- Active C
- Soil organic C
- Microbial biomass C : Soil organic C ratio

Soil parameter data were expressed as mean values per depth and analysed using a two sample Student's t-test. A significance level of $P \leq 0.01$ was established a priori. Analysis of variance (ANOVA) was used to test for monthly differences in herbage production. The data was acceptably normally distributed, but with heterogeneous herbage production variances.

Results: What information do the indicators provide?

The production rate of kikuyu-ryegrass pasture increased during August to October as the soil temperatures increased (Figure 2). Conversely the production rate decreased during February to April with a decrease in soil temperatures. The monthly productions were lowest during December and did not differ from November and August ($P > 0.05$). The low productions during November and December were as a result of a change in botanical composition; where the annual ryegrass component reached the end of its growing cycle and died, while the production rate of kikuyu started to increase (Botha 2003 and van der Colf et al. 2010). The monthly productions were highest during February and March, at this stage the annual ryegrass has died out and does not have any inhibiting effects on kikuyu production ($P > 0.05$).

Temperature of the soil environment is important to many living organisms. Temperature strongly influences the rates of all metabolic processes in plants, and therefore affects plant production. When the sun shines on the soil surface, some of its energy is absorbed, heating the soil surface. The amount of heat that can be stored in soil depends on water, gas (bulk density) and mineral fractions (clay and sand content) (Campbell and Norman, 1998). Temperate grass species, such as ryegrass are better adapted to cooler soil temperatures, whereas sub-tropical grasses, such as kikuyu, prefer soil temperatures above 18 °C for initiation of growth.

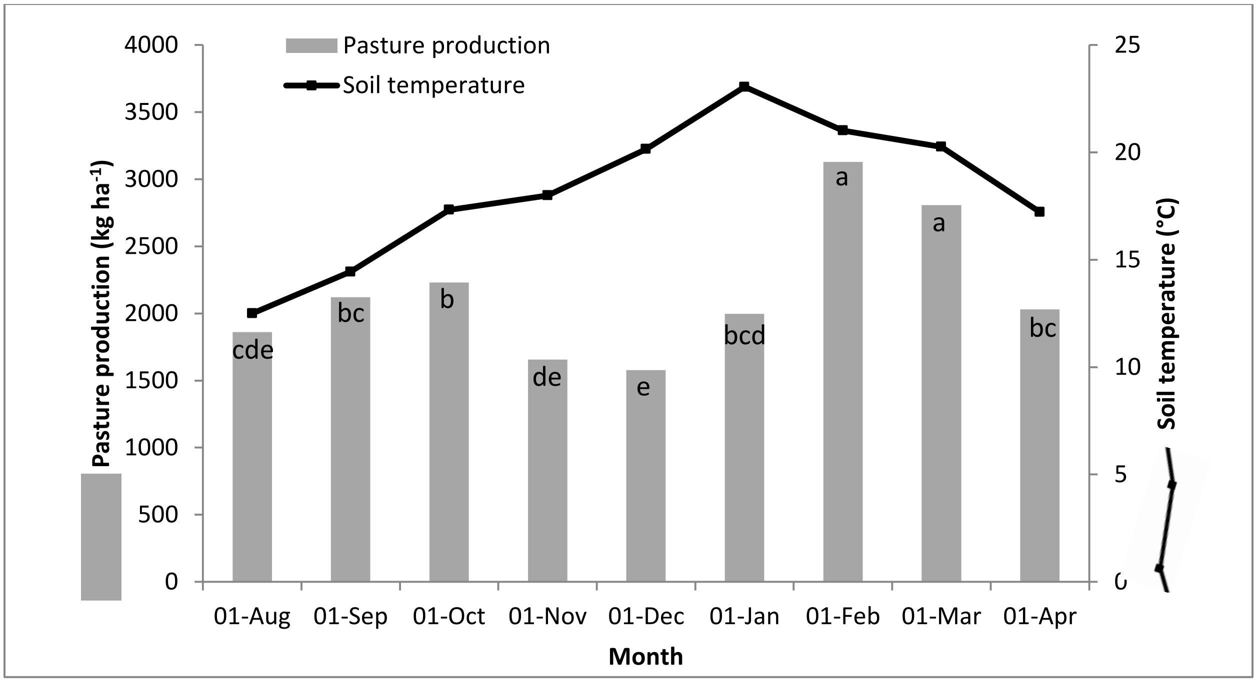


Figure 2: Monthly aboveground phytomass production (kg ha^{-1}) of kikuyu-ryegrass pasture and mean soil temperature. No common letter indicates significant differences with a least significant difference (P = 0.05) of 341.8 kg DM ha^{-1}; CV = 13.6 %; SE = 293.5; P-value < 0.001.

Chemical indicators

When a cultivated pasture on the Outeniqua Research Farm was compared to that of a conserved soil that had never received fertilizer, it was revealed that total N, extractable P, exchangeable Ca, Mg, K and Na, extractable Cu, Mn and Zn, and CEC of the cultivated pasture soil were higher than that of the virgin soil with the exception of B and S which were similar in all layers, K in 100 – 300 mm layers and total N and CEC in the 200 – 300 mm layer (Table 1). Fertility levels in the cultivated soil were satisfactory for all nutrients. Zinc levels were high in the cultivated pasture soil but not toxic. Grasses do not require B, as such low B levels found in both the virgin soil and the cultivated soil should not affect plant growth. Cation exchange capacity was low overall in response to the low clay content. The mean pH (H_2O) and pH (KCl) was slightly acidic, but within satisfactory ranges for all sampling layers of cultivated pasture soil. The optimum pH (H_2O) and pH (KCl) is in the range of 5.5 – 6.5 and 5.0 – 5.5 respectively for kikuyu-ryegrass pastures (MVSA 2003). Optimal nutrient status, thresholds, and critical limits of chemical indicators in soil and have been well documented for kikuyu and ryegrass pastures (Beyers 1994; Botha 2003; MVSA 2003).

Table 1: Soil chemical indicator means (± SE) and P-value for 0 – 100 mm soil sampling layer

	Virgin soil mean (± SE)	Cultivated pasture soil mean (± SE)	P-value
pH (KCl)	4.1 ± 0.052	5.46 ± 0.023	≤0.001
pH (H_2O)	5.3 ± 0.052	6.08 ± 0.024	≤0.001
Resistance (Ohm)	2075 ± 140.78	549 ± 21.340	≤0.001
Ca (cmol kg^{-1})	2.31 ± 0.087	5.90 ± 0.069	≤0.001
Mg (cmol kg^{-1})	1.10 ± 0.009	3.20 ± 0.041	≤0.001
Na (mg kg^{-1})	24.5 ± 1.258	102.53 ± 4.708	≤0.001
K (mg kg^{-1})	91.0 ± 7.874	146.60 ± 9.296	≤0.001
T-Value	6.27 ± 0.143	10.53 ± 0.141	≤0.001
P (mg kg^{-1})	10.50 ± 0.563	127.93 ± 4.308	≤0.001
Cu (mg kg^{-1})	0.18 ± 0.001	2.77 ± 0.056	≤0.001
Zn (mg kg^{-1})	0.77 ± 0.075	34.85 ± 1.121	≤0.001
Mn (mg kg^{-1})	7.87 ± 0.742	48.04 ± 1.375	≤0.001
B (mg kg^{-1})	0.37 ± 0.027	0.43 ± 0.018	0.138
S (mg kg^{-1})	4.76 ± 0.245	5.097 ± 0.201	0.478
Total N (%)	0.17 ± 0.006	0.42 ± 0.006	≤0.001
C:N	17.33 ± 0.921	11.09 ± 0.126	≤0.001
CEC (mg kg^{-1})	3.99 ± 0.342	5.761 ± 0.165	≤0.001

Farmer's focus point

It is important that farmers carefully manage their soil's chemical component to be balanced and nutritionally adequate for sustainable pasture production. Fertilization should be sensibly managed in order to gradually alleviate any soil chemical deficiencies and consequently maintain the nutrient balances by providing a sufficient and balanced supply of fertilizer and lime. This can only be achieved by regular (annual or biennial) soil analysis with knowledgeable recommendations.

Physical indicators

Bulk density and penetration resistance are indicators of physical resistance or compaction (Herrick 2000). It is described by the lower asymptotic function ('less-is-better'), because of the adverse effects of compaction on root penetration, soil porosity, air permeability (Carter 1990, Andrews et al. 2004), soil microbial biomass and respiration (Arshad and Martin 2002) and therefore also relative crop yields (Carter 1990). Bulk density was similar ($P > 0.01$) in the 0 – 200 mm sampling layers, but was higher (P ≤ 0.01) in the 200 – 300 mm layer of the cultivated pasture soil (Figure 3). Similar results have been reported by various studies (Doran 1987, Sparling et al. 2004, Sun et al. 2011), but contradictory results have also been found (Gál et al. 2007, Thomas et al. 2007, Yang and Wander 1999). Penetration resistance, as another method to measure compaction, showed that cultivated land had a higher (P ≤ 0.01) penetration resistance than virgin soil, but should not be a hindrance for root penetration (Figure 4). This is in agreement with findings of several authors (Bollero and Wander 1999, Cantero-Martínez and Lampurlanés 2003, Ehlers et al. 1983, Karunatilake and van Es 2002, Reeves 1997). Certain agricultural practices, especially tillage, may induce soil compaction in the topsoil forming a plough layer (Verhulst et al. 2010). From the bulk density and penetration resistance data it is evident that the soil from no-till kikuyu-ryegrass pastures was more compacted at 200 – 300 mm deep than virgin soil. Virgin soil should provide an indication of the optimum bulk density and penetration resistance at the relevant depth increments, as it reflects the inherent physical resistance of the relevant soils. The threshold value for root penetration is reported to be 2000 kPa under conventional tillage and 3000 – 5000 kPa under conservation tillage. The higher threshold value under no-till practices is due to the preservation of bio-channels (Mendoza et al. 2008). Penetration resistance values on the study site fell well below that of the threshold values for root penetration.

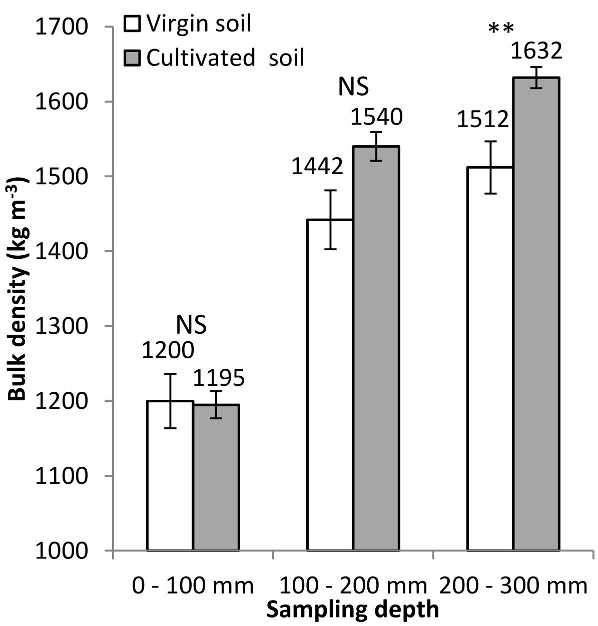


Figure 3: Bulk density (kg m^{-3}) (± SE) of cultivated pasture soil and virgin soil in close proximity. ** indicates significance between sites at P ≤ 0.01 within a certain depth class (0 – 100; 100 – 200 or 200 – 300 mm) and NS indicate no significant difference (P > 0.01).

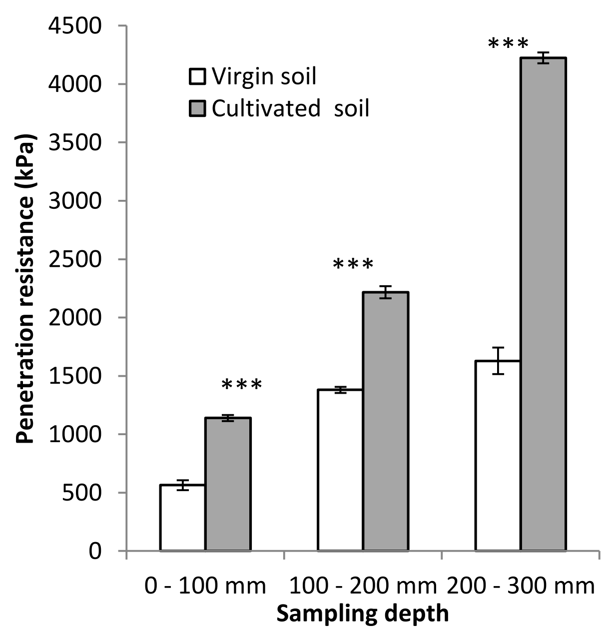


Figure 4: Penetration resistance (kPa) (± SE) of cultivated pasture soil and virgin soil in close proximity. *** indicates significance between sites at P ≤ 0.001 within a certain depth class (0 – 100; 100 – 200 or 200 – 300 mm).

Water stable aggregate percentage (WSA %) did not differ ($P > 0.01$) between cultivated pasture soil and virgin soil within any soil depth class (Table 2). It is evident that the relevant minimum-till practices applied to the cultivated pasture soil do not have any adverse effects on the soil microstructure. Aggregate stability reflects the strength of the microstructure of soil. It involves a wide range of physical, biological and geochemical functions in soil which affects root proliferation, porosity and water movement, infiltration rate, erodibility, microbial community structure, stabilization of soil organic matter (SOM) and crop performance (Carter et al. 1997, Amezketa 1999, Bronick and Lal 2005, Mendoza et al. 2008). Due to the multi-faceted influence of aggregate stability it is regarded as a key physical indicator of soil quality (Verhulst et al. 2010) and is described with a higher asymptotic function (Andrews et al. 2004). The investigated soils are sandy and mainly depend on cations and SOM, rather than clay, to form stable aggregates (Bronick and Lal 2005). Perennial crops should maintain aggregate stability at relatively high levels (Haynes et al. 1991). No significant difference between the aggregate stability of cultivated pasture soil and virgin soil was found. This indicates that pasture has no impact on the aggregate stability of soil due to the stoloniferous and rhizomateous physiology of perennial kikuyu grass.

Table 2: Water stable aggregate (WSA) % (± SE) and P-value three soil sampling layers

Sampling layer	Virgin soil (± SE)	Cultivated pasture soil (± SE)	P-value
0 – 100 mm	83.75 ± 1.12	76.56 ± 1.30	0.021
100 – 200 mm	76.02 ± 2.12	69.09 ± 1.56	0.066
200 – 300 mm	72.67 ± 2.58	61.86 ± 2.30	0.050

Farmer's focus point

Farmers should be familiar with their soil's physical characteristics. Some physical characteristics are inherent and cannot change. It is therefore important for farmers to know their soil's behaviour and consequently only select crops that will be best suited to the specific soil form. Other soil physical characteristics are dynamic and can be altered by management. Changes in soil compaction figures (bulk density or penetration resistance) can alert farmers to changes in soil quality and health. An increase in these figures indicates a degrading environment and is undesirable.

Biological indicators

The steady state C:N ratio provided a useful guideline to N release or mineralization patterns (Bronick and Lal 2005) and PMN revealed the capacity of the soil to supply mineralized N from SOM reserves with aid from microbes (Idowu et al. 2009, Edenborn et al. 2011). The vertical distribution of PMN was similar ($P > 0.01$) at 0 – 100 mm soil depth, but higher ($P \leq 0.01$) in the cultivated pasture soil than in the virgin soil at depths deeper than 100 mm (Figure 5).

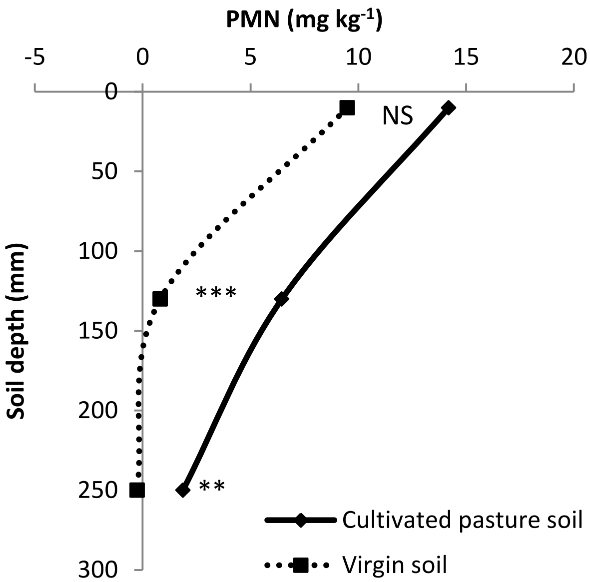


Figure 5: Potentially mineralizable nitrogen (PMN) of cultivated pasture soil and virgin soil in close proximity. ** and *** indicate significance between sites at P ≤ 0.01 and P ≤ 0.001 respectively and NS indicate no significant difference (P > 0.01).

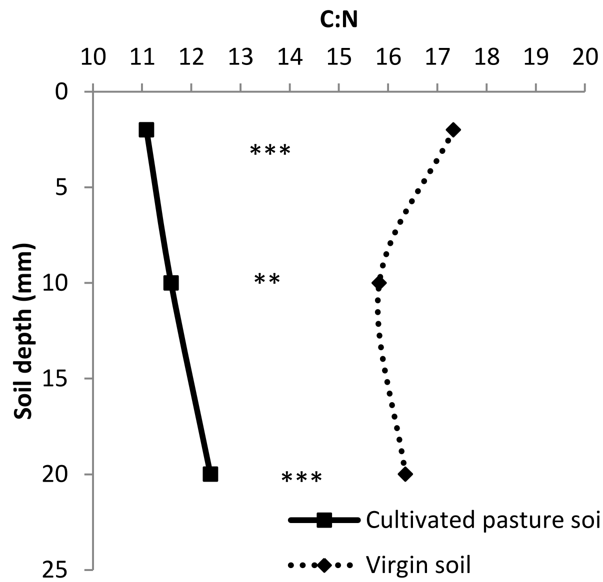


Figure 6: Mean C:N ratio of cultivated pasture soil and virgin soil in close proximity. *** indicates significance between sites within a depth class at P ≤ 0.001 and ** at P ≤ 0.01.

Very low or negative values were observed in the virgin soil deeper than 100 mm. PMN decreased at a steady rate at both sites, but approached zero at a depth of ca. 100 mm in the virgin soil. The C:N ratio was markedly lower (P ≤ 0.01) in the cultivated pasture soil than in the virgin soil in all sampling layers (Figure 6). The C:N ratio within all sampling layers in both soils was narrower than 25:1, which is considered the threshold for rapid mineralization (Miles and Manson 2000, Brady and Weil 2004). Cultivated pasture soil had C:N ratios of around 12 which was in the range normally reported for agricultural soil (Karlen et al. 1999, Cerri et al. 2006, Ernst and Siri-Prieto 2009). The recommended C:N ratio of a healthy soil organic C turnover rate in well managed pasture is between 10 – 12 (Miles and Manson 2000). However, N applications of 30 kg N ha^{-1} after every grazing cycle (28 – 35 days), is high and might lower the C:N ratio to the observed values. The influence of this C:N ratio on the sustainability of the agro-ecosystem, whilst productions remain adequate for dairy production systems, is unclear and requires further research. The higher C:N ratio in virgin soil is indicative of the undisturbed and sustainable state of the ecosystem, but a very low grazing capacity (i.e. 77 ha LSU-1) also applies (Boshoff et al. 2001). Due to low productivity natural Renosterveld species require relatively low N levels to function in a sustainable manner, rendering the C:N ratio higher. This was also evident from PMN results. The potential of the microbes to mineralize N was higher in the cultivated pasture soil than in the virgin soil. PMN is an important link between soil microbial function and plant productivity

(Andrews et al. 2004). It is described by a higher asymptotic function (Andrews et al. 2004), in other words, the higher the PMN value, the better.

SOM influences almost all soil functions and properties and is of the utmost importance for sustaining plant productivity and environmental quality. High SOM is one of the best single indicators of a high quality soil (Larson and Pierce 1991). SOM can be divided into different components each of which state different characteristics or functions in soil. To be able to compare sites and to study the pedological significance of the data, the soil organic matter related measurements were expressed as tons per hectare soil (kg stock per m^{-3}) by correction for bulk density (Figure 3) (Arshad and Martin 2002).

Soil organic C concentration decreased with depth, but at a higher rate in the cultivated pasture soil than in the virgin soil (Figure 7). The difference of this effect between cultivated pasture soil and the virgin soil was highly significant ($F_{29,\ 5} = 5.10$; $P \leq 0.001$). The highest concentration of soil organic C was detected in the 0 – 100 mm layer for cultivated pasture soil at 34.30 ± 0.72 t ha^{-1} and differed from that of the virgin soil at 17.09 ± 0.60 t ha^{-1} ($F_{29,\ 5} = 7.08$; $P \leq 0.001$). Soil organic C content in the 100 – 200 mm layer was even higher ($P \leq 0.01$) in the cultivated pasture soil, but did not differ in the 200 – 300 mm layer ($P > 0.01$).

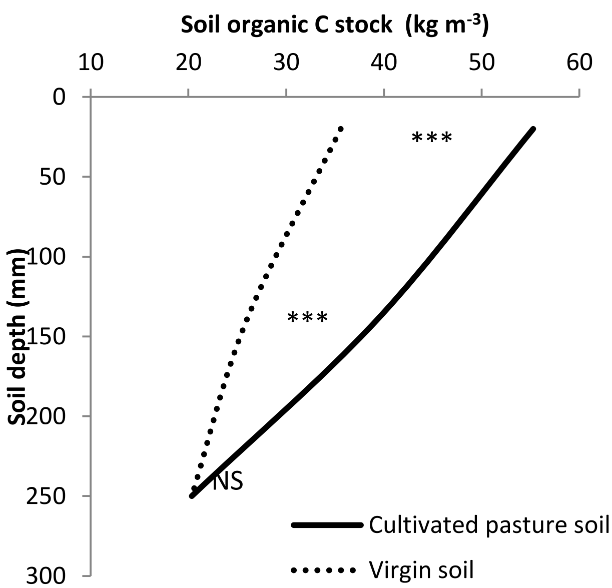


Figure 7: Mean soil organic C stock of cultivated pasture soil and virgin soil in close proximity. *** indicate significance between sites within a depth class (0 – 100; 100 – 200 or 200 – 300 mm) at $P \leq 0.001$ and NS indicate no significant difference ($P > 0.01$).

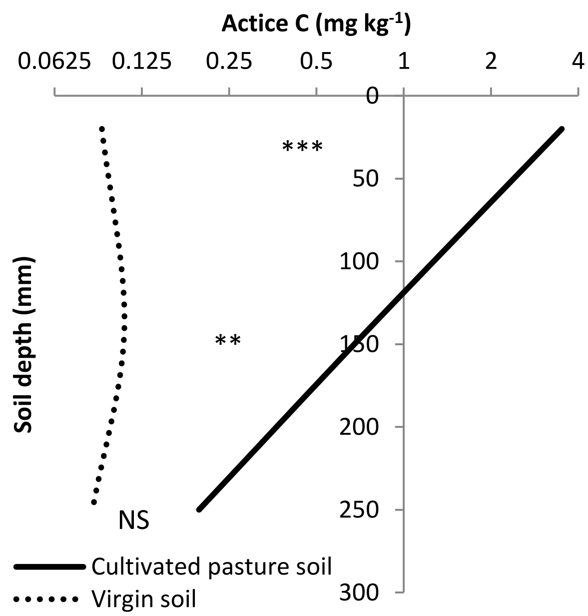


Figure 8: Mean active C content of cultivated pasture soil and virgin soil in close proximity indicated on a logarithmic x-axis. ** and *** indicate significance between sites within a depth class (0 – 100; 100 – 200 or 200 – 300 mm) at $P \leq 0.01$ and $P \leq 0.001$ respectively and NS indicate no significant difference ($P > 0.01$).

Active C content was very low in the virgin soil (between 0.406 ± 0.003 and 0.523 ± 0.001 g m^{-3}). It was fairly uniformly distributed within the top 300 mm of soil (Figure 8). The active C concentration in the cultivated pasture soil was ca. 40 times higher ($P \leq 0.01$) than in the virgin soil at 0 – 100 and 100 – 200 mm soil layers, but was similar in the 200 – 300 mm soil layer. Active C indicates the amount of organic matter available for biological functioning in soil (Idowu et al. 2008). Active C did not provide any further information on soil organic C or LOI and was concurrent with the findings of Idowu et al. (2009). Because active C analysis is expensive and does not provide additional insight on soil quality status, it is unnecessary for farmers in the southern Cape to perform this analysis routinely.

The microbial biomass plays an important role in organic matter decomposition and nutrient cycling (Granatstein et al. 1987). Mean microbial biomass carbon was used to investigate the action of soil microbes within the SOM cycle (Carter 1986). MBC in the virgin soil was relatively uniformly distributed throughout all soil layers. Mean MBC in cultivated pasture soil was higher in the 0 –100 mm and 100 – 200 mm layers (F29, 5 = 10.03; $P \leq 0.001$ and F29, 5 = 5.81; P = 0.001 respectively) (Figure 9), which is concurrent to the findings of Carter (1986). MBC in the cultivated pasture soil decreased sharply in the 200 – 300 mm layer to a point where it was similar to that of the cultivated soil (F29, 5 = 2.00; P = 0.092). The higher MBC content in the cultivated pasture soil than in the virgin soil could be ascribed to the vigorous and large mass root systems of the kikuyu-ryegrass pasture within improved external environmental conditions such as water supply by irrigation, nutrient supply by fertilization and liming. However, several studies have reported seasonal changes in MBC (Granatstein et al. 1987, Sparling et al. 1990, Sparling 1992, Martens 1995, Moore et al. 2000).

Mean LOI of the cultivated pasture soil was higher in the 0 – 100 mm and 100 – 200 mm layers than in virgin soil layers (F29, 5 = 1.16; $P \leq 0.001$ and F29, 4 = 2.10; $P \leq 0.001$ respectively), but was similar in the 200 – 300 mm soil layer. Loss-on-ignition is a rapid and simple method to accurately estimate SOM (Jacobs et al. 2002, Swanepoel and Botha 2012). Such simplified procedures have merit with farmers as important links between science and practice in assessment of soil quality (Doran 2002). LOI and soil organic C levels were highly correlated and responded in a similar manner. Even though LOI did not provide valuable additional information, it would still be recommended as a valuable indicator for soil quality due to the practicality of the procedure.

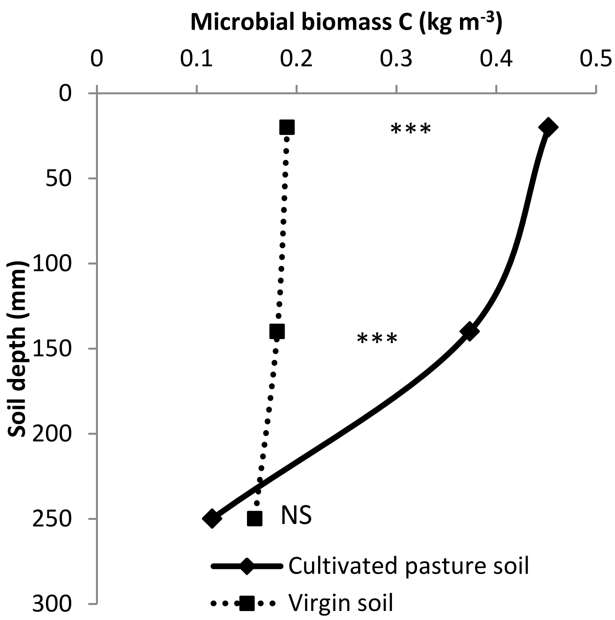


Figure 9: Mean microbial biomass C content of cultivated pasture soil and virgin soil in close proximity. *** indicate significance between sites within a depth class (0 – 100, 100 – 200 or 200 – 300 mm) at P ≤ 0.001 and NS indicate no significant difference (P > 0.01).

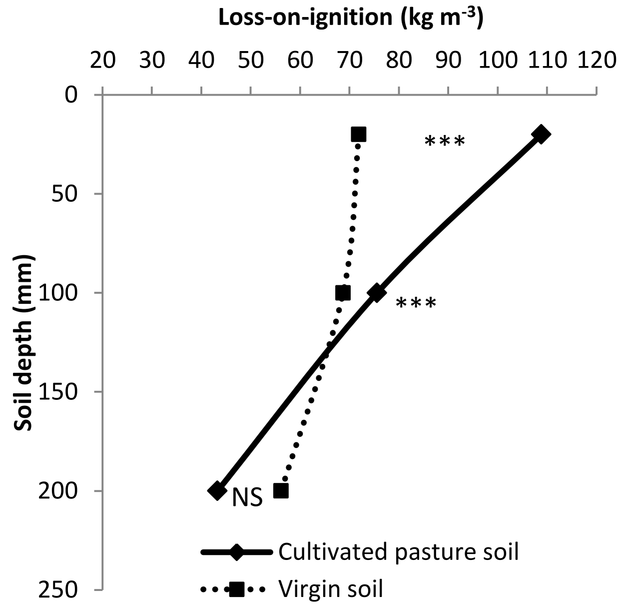


Figure 10: Mean loss-on-ignition (LOI) of cultivated pasture soil and virgin soil in close proximity. *** indicates significance between sites within a depth class (0 – 100, 100 – 200 or 200 – 300 mm) at P ≤ 0.001 and NS indicate no significant difference (P > 0.01).

Granatstein (1987) reported that MBC and total C responded similarly with land use, as was the result in this case. The ratios between sites suggest that the microbial community's substrate-use efficiency and their ability to decompose a range of SOM sources was similar (Moore et al. 2000) The relatively strong correlations reported between MBC and soil organic C indicated the importance of the microbes regulating SOM transformations (Mäder et al. 2002). Insam and Domsch (1988) stated that the MBC:soil organic C ratio serves as an indicator of C accumulation or release. This ratio should be used as a reference point during steady-state conditions (Martens 1995). The assumption was made that the virgin soil is in equilibrium and sustainable for its relevant land use; the MBC:soil organic C ratio should therefore reflect baselines for the ratio. The MBC:soil organic C ratio of the cultivated pasture soil were statistically similar (P > 0.01) to that of the virgin soil and indicated that the cultivated soil is also under steady-state conditions. Sudden deviations from this level should indicate that the system is changing and C is being released or accumulated. The ratio is therefore a valuable tool to predict C sequestration actions. MBC:soil organic C ratio baseline values are shown in Table 3. Smaller values than those shown in Table 3 would indicate that the availability of C for microbial functioning is low (Insam and Domsch 1988, Moore et al. 2000). In such a case, an amendment to the soil which will provide easily decomposable SOM will be valuable (Moore et al. 2000).

Table 3: Microbial biomass carbon to soil organic carbon ratio (%) ± standard error of mean (SEM), F ratio and P-value three soil sampling layers

Sampling layer	Virgin soil (± SEM)	Cultivated pasture soil (± SEM)	F ratio	P-value
0 – 100 mm	0.537 ± 0.068	0.835 ± 0.062	$F_{29, 5} = 4.17$	0.045
100 – 200 mm	0.706 ± 0.12	0.953 ± 0.044	$F_{28, 5} = 1.48$	0.031
200 – 300 mm	0.650 ± 0.056	0.560 ± 0.046	$F_{29, 5} = 3.32$	0.404

In general, all soil organic matter related indicators (soil organic C, active C, MBC and LOI) 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 200 – 300 mm soil layer. The surface sampling layer was recognized by darkening caused by the accumulation of SOM in the form of humus. The accumulation of SOM in the surface layer is expected to be at a maximum in the topsoil.

Farmer's focus point

The conserved, undisturbed soil's surface layer had an inherent organic C content of 36 t ha^{-1} or 3 % C. Researchers in the southern Cape recommend a critical threshold of soil organic C levels higher than 2 % for optimum DM production and persistence of kikuyu-ryegrass systems (Botha 2008). The validity of this figure raises concern, since there is a lack of quantitative evidence for and against this. According to this study, virgin soil is able to sustain soil organic C levels of 3 % and provides proof that the critical threshold should rather be above 3 % C. It is recommended that farmers should manage similar pastures to have values of at least that found in the virgin soil.

Indicators of sustainability of soil such as the microbial biomass C : soil organic C ratio, C:N ratio and PMN can be used as valuable tools to predict any changes occurring from external factors that may alter the equilibrium in soil.

Conclusion

The cultivated no-till pasture was highly productive and should be at equilibrium within the current management structure. Chemical, physical and biological properties of the cultivated pasture soil were interpreted by comparison with a virgin soil which remained undisturbed and had a very low grazing capacity. Chemical indicators were within the recommended thresholds for a cultivated pasture and supported the kikuyu-ryegrass production system. Bulk density and penetration resistance showed that cultivated pastures were more compacted at 200 – 300 mm deep than virgin soil and the latter should indicate the optimum critical thresholds. PMN and the C:N ratio provided evidence that the potential of the microbes to mineralize N was higher in cultivated pasture than in virgin soil. SOM related indicators (soil organic C, active C, MBC and

LOI) 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 deeper soil layers.

Message to the farmer

Chemical balances and nutrient levels of soil should be maintained by regular soil analyses with knowledgeable recommendations

Physical properties of soil determine which crop should be cultivated. Compaction is an important physical indicator of soil quality and should be kept to a minimum.

Biological sustainability of soil (the living portion of soil) depends on soil organic C content which should be kept at levels higher than 3% C in southern Cape soils

Proper functioning of the soil necessitates sound management of the chemical, physical and biological components of soil.

References

Andrews SS, Karlen DL and Cambardella CA. 2004. The Soil Management Assessment Framework: A Quantative Soil Quality Evaluation Method. Soil Sci. Soc. Am. J. 68: 1945-1962.

Beyers, CP de L. Die bemesting van aangeplante weidings. In: Weidings = Pastures : 1994 / Departement van Landbou, Elsenburg : Dept van Landbou, 1994, 86 – 93.

Bone J, Head M, Barraclough D, Archer M, Scheib C, Flight D and Voulvoulis N. 2010. Soil quality assessment under emerging regulatory requirements. Environ. Int. 36: 609-622.

Botha, PR (2008) Factors influencing the persistence and production potential of kikuyu (Pennisetum clandestinum) over-sown with different ryegrass and clover species in the southern Cape. In: The production potential of pasture for milk and beef production: Proceedings of the Department of Agriculture Western Cape's Outeniqua Research Farm Information day. p 30 – 40.

Amezketa E (1999) Soil aggregate stability: A review. J Sustainable Agric 14:83-151

Andrews SS, Cambardella CA, Karlen DL (2004) The soil management assessment framework. Soil Sci Soc Am J 68:1945-1962

Arshad M, Martin S (2002) Identifying critical limits for soil quality indicators in agro-ecosystems. Agric , Ecosyst Environ 88:153-160

Bollero G, Wander M (1999) Soil quality assessment of tillage impacts in Illinois. Soil Sci Soc Am J 63:961-971

Botha PR (2003). Die produksiepotensiaal van oorgesaaide kikoejoeweiding in die gematigde kusgebied van die Suid-Kaap

Brady NC, Weil RR (2004) Elements of the nature and properties of soils. Prentice Hall

Bronick C, Lal R (2005) Soil structure and management: a review. Geoderma 124:3-22

Cantero-Martínez C, Lampurlanés J (2003) Soil bulk density and penetration resistance under different tillage and crop management systems and their relationship with barley root growth. Agron J 95:526-536

Carter MR, Gregorich E, Anderson D, Doran J, Janzen H, Pierce F (1997) Concepts of soil quality and their significance. Dev Soil Sci 25:1-19

Carter M (1990) Relative measures of soil bulk density to characterize compaction in tillage studies on fine sandy loams. Can J Soil Sci 70:425-433

Carter MR. 1986. Microbial biomass as an index for tillage-induced changes in soil biological properties. Soil & Tillage Research 7: 29-40.

Carter MR. 1996. Concepts of Soil Quality. Soil Quality is in the Hands of the Land Manager.

Doran JW and Parkin TB. 1994. Defining and assessing soil quality. In: JW Doran, DC Coleman, DF Bezdicek and BA Stewart (eds), Defining Soil Quality for a Sustainable Environment: SSSA special publication. Soil Science Society of America, Madison. pp

Doran JW, Sarrantonio M and Liebig MA. 1996. Soil Health and Sustainability. Academic Press, Inc., Doran JW and Zeiss MR. 2000. Soil health and sustainability: managing the biotic component of soil quality. Applied Soil Ecology 15: 3-11.

Doran J (1987) Microbial biomass and mineralizable nitrogen distributions in no-tillage and plowed soils. Biol Fertility Soils 5:68-75

Edenborn S, Sexstone A, Sutanto Y, Chapman J (2011) Relationships among Contrasting Measurements of Microbial Dynamics in Pasture and Organic Farm Soils. Applied and Environmental Soil Science 2011

Ehlers W, Köpke U, Hesse F, Böhm W (1983) Penetration resistance and root growth of oats in tilled and untilled loess soil. Soil Tillage Res 3:261-275

Ernst O, Siri-Prieto G (2009) Impact of perennial pasture and tillage systems on carbon input and soil quality indicators. Soil Tillage Res 105:260-268

Fey M, Hughes J, Lambrechts J, Mills A (2010) Soils of South Africa. Cambridge Univ Pr

Gál A, Vyn TJ, Michéli E, Kladivko EJ, McFee WW (2007) Soil carbon and nitrogen accumulation with long-term no-till versus moldboard plowing overestimated with tilled-zone sampling depths. Soil Tillage Res 96:42-51

Granatstein DM, Bezdicek D, Cochran V, Elliott L, Hammel J (1987) Long-term tillage and rotation effects on soil microbial biomass, carbon and nitrogen. Biol Fertility Soils 5:265-270

Haynes R, Swift R, Stephen R (1991) Influence of mixed cropping rotations (pasture-arable) on organic matter content, water stable aggregation and clod porosity in a group of soils. Soil Tillage Res 19:77-87

Herrick JE (2000) Soil quality: an indicator of sustainable land management?. Applied Soil Ecology 15:75-83

Idowu OJ, van Es HM, Abawi GS, Wolfe DW, Ball JI, Gugino BK, Moebius BN, Schindelbeck RR, Bilgili AV (2008) Farmer-oriented assessment of soil quality using field, laboratory, and VNIR spectroscopy methods. Plant Soil 307:243-253

Idowu O, Van Es H, Abawi G, Wolfe D, Schindelbeck R, Moebius-Clune B, Gugino B (2009) Use of an integrative soil health test for evaluation of soil management impacts. Renewable Agriculture and Food Systems 24:214-224

Insam H, Domsch K (1988) Relationship between soil organic carbon and microbial biomass on chronosequences of reclamation sites. Microb Ecol 15:177-188

Jacobs PM, Talaga BJ, Burras CL, Mason JA, Konen ME (2002) Equations for predicting soil organic carbon using loss-on-ignition for north central US soils. Soil Sci Soc Am J 66:1878-1881

Jaenicke EC and Lengnick LL. 1999. A Soil-Quality Index and Its Relationship to Efficiency and Productivity Growth Measures: Two Decompositions. American Journal of Agricultural Economics 81: 881-893.

Karlen DL, Buhler DD, Ellsbury MM and Andrews SS. 2002. Soil, Weed and Insect Management Strategies for Sustainable Agriculture. Journal of Biological Sciences 2: 58-62.

Karlen DL, Ditzler CA and Andrews SS. 2003. Soil quality: why and how? Geoderma 114: 145-156.

Karlen DL, Mausbach MJ, Doran JW, Cline RG, Harris RF and Schuman GE. 1997. Soil Quality: A Concept, Definition, and Framework for Evaluation. Soil Sci. Soc. Am. J. 61: 4-10.

Karlen D, Rosek M, Gardner J, Allan D, Alms M, Bezdicek D, Flock M, Huggins D, Miller B, Staben M (1999) Conservation Reserve Program effects on soil quality indicators. J Soil Water Conserv 54:439-444

Karunatilake U, Van Es H (2002) Rainfall and tillage effects on soil structure after alfalfa conversion to maize on a clay loam soil in New York. Soil Tillage Res 67:135-146

Lal R (1998) Soil quality and agricultural sustainability. CRC

Larson W, Pierce F (1991) Conservation and enhancement of soil quality. Evaluation for sustainable land management in the developing world 2:175-203

Mäder P, Fliessbach A, Dubois D, Gunst L, Fried P, Niggli U (2002) Soil fertility and biodiversity in organic farming. Science 296:1694

Martens R (1995) Current methods for measuring microbial biomass C in soil: potentials and limitations. Biol Fertility Soils 19:87-99

Mendoza R, Franti T, Doran J, Powers T, Zanner C (2008) Tillage Effects on Soil Quality Indicators and Nematode Abundance in Loessial Soil under Long-Term No-Till Production. Commun Soil Sci Plant Anal 39:2169-2190

Moore J, Klose S, Tabatabai M (2000) Soil microbial biomass carbon and nitrogen as affected by cropping systems. Biol Fertility Soils 31:200-210

Nielsen MN, Winding A (2002) Microorganisms as indicators of soil health. National Environmental Research Institute Denmark

Reeves D (1997) The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil Tillage Res 43:131-167

Soil Classification Working Group (1991) A Taxonomic System for South Africa Soil and Irrigation Research Institute. Department of Agricultural Development

Sojka RE, Upchurch DR and Borlaug NE. 2003. Quality soil management or soil quality management: performance versus semantics. Advances in Agronomy 79: 1-68.

Sparling GP (1992) Ratio of microbial biomass carbon to soil organic carbon as a sensitive indicator of changes in soil organic matter. Soil Research 30:195-207

Sparling G, Schipper L, Bettjeman W, Hill R (2004) Soil quality monitoring in New Zealand: practical lessons from a 6-year trial. Agric , Ecosyst Environ 104:523-534

Sun B, Hallett PD, Caul S, Daniell TJ, Hopkins DW (2011). Distribution of soil carbon and microbial biomass in arable soils under different tillage regimes. Plant Soil 338:17-25

Swanepoel P, Botha P (2012) Predicting soil organic carbon content from loss-on-ignition.

Thomas G, Dalal R, Standley J (2007) No-till effects on organic matter, pH, cation exchange capacity and nutrient distribution in a Luvisol in the semi-arid subtropics. Soil Tillage Res 94:295-304

Van der Colf J. 2010. The production potential of Kikuyu (Pennisetum clandestinum) pastures over-sown with Ryegrass (Lolium spp.). MSc(Agric), University of Pretoria, Pretoria.

Van der Colf J, Botha P, Meeske R, Truter W (2011) Kikuyu over-sown with Italian, Westerwolds or perennial ryegrass: dry matter production, botanical composition and nutritional value. The production potential of Kikuyu (Pennisetum clandestinum) pastures over-sown with Ryegrass (Lolium spp.):94

Verhulst N, Govaerts B, Verachtert E, Castellanos-Navarrete A, Mezzalama M, Wall P, Chocobar A, Deckers J, Sayre K (2010) Conservation agriculture, improving soil quality for sustainable production systems. Advances in soil science: food security and soil quality.CRC Press, Boca Raton 137:C208

Yang XM, Wander MM (1999) Tillage effects on soil organic carbon distribution and storage in a silt loam soil in Illinois. Soil Tillage Res 52:1-9

PRODUCTION OF *BRASSICA*, *BETA*, *RAPHANUS* AND *CICHORIUM* SPECIES IN THE SOUTHERN CAPE OF SOUTH AFRICA

MM Lombard[1], J van der Colf[1] & PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

Grass and legume pastures are widely used as fodder for dairy and beef cattle in the southern Cape. The period of low production in the fodder flow are filled with a variety of grains, but there is still a need for a high quality crop that can produce sufficient amounts of dry matter (DM) during the summer and autumn. A possible alternative is annual forage crops, which include forage rape (*Brassica napus*), forage turnip (*B. rapa*), Kales (*B. oleracea*), Swedes (*B. napobrassica*), fodder beet (*Beta vulgaris*), Japanese radish (*Raphanus sativus*) and Chicory (*Cichorium intybus)*. Unfortunately, limited or no information is available on the production potential of these species in the southern Cape.

Annual forage crop species are mainly used as fodder in the summer rainfall areas of South Africa (Kynoch Pasture Handbook 2004). This is due to the reliable rainfall and favorable temperatures during the growth period in above mentioned areas (Kynoch Pasture Handbook 2004). These species are quick to establish and produce large amounts of forage during summer and autumn for cattle and sheep (Hall and Jung 1994; Ayres 2002; Kynoch Pasture Handbook 2004, Hogh-Jensen *et al*., 2006; Khogali *et al*., 2011). Leaves, stems and/or bulbs can be utilized as forage, depending on the species (Bartholomew and Underwood nd; Hall and Jung 1994; Krall *et al*., 1996; Wilson *et al*., 2004; Hall and Jung 2005; Turki and Khogali 2011). As forage, these crops are palatable, digestible, can provide energy and contain a high level of protein (Hall and Jung 1994; Reid *et al*., 1994; Ayres 2002; Hall and Jung 2005; Hogh-Jensen *et al*., 2006; Khogali *et al*., 2011).

The aim of this study was to evaluate the DM production potential and planting date of forage rape, forage turnip, Kales, Swedes, fodder beet, fodder radish and Chicory cultivars.

Materials and methods

This study was carried out on the Outeniqua Research Farm near George (Altitude 201m, 33° 58' 38" South and 22° 25' 16" East, rainfall 728 mm per annum) in the Western Cape province of South Africa. The study was executed under sprinkler irrigation on a Witfontein soil form. Irrigation scheduling was done according to tensiometer readings, commencing at –25 kPa and terminated at –10 kPa (Botha 2002). Fertilizer was applied to raise and balance the soil nutrient levels to soil analysis recommendations. Phosphorous (P) and potassium (K) will be applied before planting to raise soil nutrient levels in accordance with the soil analysis report.

The trial was planted on the 26th of November 2011. Two randomized replicates were planted on the 26th of January 2012 and 26th of March 2012. Lands were shallowly tilled with a konskilde and a seedbed was created. Seed was planted into the soil and then plots were rolled with a land roller.

The trial consisted of 17 cultivars (Table 1) and each treatment was replicated three times. The experimental design was a randomized block design with 17 treatments randomly allocated in 3 blocks. Plot size was 2.1 m x 6 m (thus 12.6 m^2). Plots were sampled by species when the species reached maturity. Each treatment was harvested destructively.

Table 1: Species, common name, cultivar, usage and growth period of the different *Brassica, Beta, Raphanus* and *Cichorium* species to be evaluated in the trial on Outeniqua Research Farm

Species	Common name	Cultivar(s)	Usage			Seeding rate
			Roots	Stems	Leaves	
Brassica rapa	Forage turnip	Dynamo Barkant Green Globe KR7809 Purple Top T-Raptor	X	X	X	3
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
Raphanus sativus	Japanese radish	Nooitgedacht	X	X	X	6
Cichorium intybus	Chicory	Chico		X	X	5

(Bartholomew and Underwood nd; Hall and Jung 1994; Krall *et al*., 1996; Hall and Jung 2005)

In the case of the forage rapes, Kales and Chicory, a strip of pasture (1.5 m x 4 m = 6 m^2) was cut on a height of 100 mm to be used for pasture sampling. The weight of the cut strip was determined, after which approximately 500g of the sample was placed in a brown paper bag and weighed wet and dry to determine DM content. The sample was dried in an oven at 60°C for 72 hours to determine dry weight.

The forage turnips, Swede, fodder beet and fodder radish were completely removed by hand. A pasture strip (1.5m x 4m = 6m^2) was used and the total weight of the sample was determined. The plants were divided into roots and above ground plant material and each fraction was weighed separately. Approximately 500g of each of the fractions were placed in a brown paper bag and weighed wet and dry to determine DM content. Samples were dried in an oven at 60°C for 72 hours to determine dry weight.

An appropriate analysis of variance was performed, the assumption of normality of the residuals tested to ensure valid and reliable results (Shapiro & Wilk, 1965). A Student LSD (least significant difference)-test at 5% significance level was done to compare the treatment means (Ott, 1998). The STATS module of SAS version 9.2 was used to analyze the data (SAS institute Inc., 2008).

Results and discussion

Table 2 indicates the dry matter (DM) production rate, DM content, DM production and days from plant to harvest of different plant fractions of annual fodder crop species planted during November 2011.

- Bulbs

Invitation and T-Raptor had the highest (P<0.05) bulb DM content. Dynamo had a similar (P>0.05) bulb DM production rate to Invitation and Barkant but higher (P<0.05) than the other bulb producing cultivars. Invitation had the highest (P<0.05) bulb DM production.

- Stems and leaves

KR6099 had a similar (P>0.05) stem/leave DM content to KR7872, Interval, Sovereign and Barnapoli but higher (P<0.05) than all the other cultivars. Interval and Nooitgedacht had a similar (P>0.05) stem/leave DM production rate to Barkant, T-Raptor, Barnapoli, KR6099 and Dynamo but higher (P<0.05) than the other cultivars. KR6099 had a similar (P>0.05) stem/leave DM production to Interval but higher (P<0.05) than the other cultivars.

- All plant fractions

KR6099 had a similar (P>0.05) mean DM content to KR7872, Interval, Sovereign and Barnapoli but higher (P<0.05) than the other cultivars. Barkant had a similar (P>0.05) mean DM production rate to Nooitgedacht, Dynamo, Interval and T-Raptor but higher (P<0.05) than the other cultivars. KR6099 had a similar (P>0.05) total DM production to Interval, Invitation, Nooitgedacht and Dynamo but higher (P<0.05) than the other cultivars.

Table 2: The dry matter (DM) production rate, DM content, DM production and days from plant to harvest of different plant fractions of annual Fodder crop species planted during November 2011 on the Outeniqua Research Farm near George.

Treatment	Days from plant to harvest	Bulbs			Stems and leaves			All plant fractions		
		DM production rate (Kg DM ha^{-1} day^{-1})	DM content (%)	DM production (Kg DM ha^{-1})	DM production rate (Kg DM ha^{-1} day^{-1})	DM content (%)	DM production (Kg DM ha^{-1})	Mean DM production rate (Kg DM ha^{-1} day^{-1})	Mean DM content (%)	Total DM production (Kg DM ha^{-1})
Dynamo	**76**	22.9^{a}	5.99^{bc}	1736^{bc}	46.7^{abc}	8.74^{gh}	3547^{cde}	69.5^{abc}	7.36^{f}	5283^{abc}
Barkant	**76**	20.9^{ab}	5.36^{bc}	1588^{bc}	52.3^{ab}	8.46^{gh}	3975^{cd}	73.2^{a}	6.91^{f}	5563^{bc}
Green Globe*	**76**	.	.	.	.	.	.	.	.	.
KR7809	**76**	11.6^{bc}	4.76^{c}	884^{bc}	37.7^{bcd}	9.79^{fgh}	2868^{cde}	49.4^{bcdef}	7.28^{f}	3751^{bcde}
Purple Top	**76**	9.43^{c}	6.87^{b}	717^{bc}	36.4^{bcd}	9.83^{fgh}	2769de	45.9^{cdef}	8.35^{f}	3485^{cde}
T-Raptor	**76**	5.78^{c}	10.0^{a}	440^{c}	47.7^{abc}	8.69^{gh}	3627^{cde}	53.5^{abcde}	9.32^{ef}	4066^{bcde}
Barnapoli	**97**	.	.	.	47.5^{abc}	14.1^{abcd}	4610^{bcd}	47.5^{cdef}	14.1^{abcd}	4610^{bcde}
KR7872	**97**	.	.	.	40.7^{bcd}	15.4^{ab}	3948^{cd}	40.7^{defg}	15.4^{ab}	3948^{bcde}
Interval	**97**	.	.	.	62.7^{a}	14.9^{abc}	6085^{ab}	62.7^{abcd}	14.9^{abc}	6085^{ab}
Spitfire	**97**	.	.	.	36.3^{bcd}	13.2^{bcde}	3519^{cde}	36.3^{efgh}	13.2^{bcd}	3519^{cde}
Caledonian	**163**	.	.	.	21.4^{def}	12.3^{cdef}	3483^{cde}	21.4^{gh}	12.3^{cd}	3483^{cde}
KR6099	**163**	.	.	.	47.4^{abc}	16.1^{a}	7723^{a}	47.4^{cdef}	16.1^{a}	7723^{a}
Sovereign	**163**	.	.	.	29.3^{cde}	14.8^{abcd}	4778^{bcd}	29.3^{fgh}	14.8^{abcd}	4778^{bcd}
Invitation	**163**	22.3^{ab}	11.1^{a}	3637^{a}	11.3^{ef}	12.8^{bcde}	1843^{ef}	33.6^{efgh}	11.9^{de}	5480^{abc}
Brigadier	**163**	11.4^{bc}	6.22^{bc}	1860^{b}	2.11^{f}	10.9^{efg}	344^{f}	13.5^{h}	8.57^{f}	2204^{e}
Nooitgedacht	**76**	8.11^{c}	5.78^{bc}	616^{bc}	63.5^{a}	7.28^{h}	4823^{bc}	71.6^{ab}	6.53^{f}	5440^{abc}
Chico	**97**	.	.	.	29.0^{cde}	12.0^{def}	2813^{cde}	29.0^{fgh}	12.0^{de}	5813de
LSD (0.05)		**10.916**	**1.921**	**1341.9**	**20.137**	**2.909**	**2042.5**	**23.732**	**2.860**	**2443.1**

^{abcde} Means with no common superscript differ significantly; LSD = Least significant difference at P = 0.05; *Green Globe failed to germinate and emerge

Table 3 indicates the dry matter (DM) production rate, DM content, DM production and days from plant to harvest of different plant fractions of annual Fodder crop species planted during January 2012.

- Bulbs

Invitation had the highest (P<0.05) bulb DM content. Invitation and Brigadier had the highest (P<0.05) bulb DM production rate and the highest (P<0.05) bulb DM production.

- Stems and leaves

KR6099 had a similar (P>0.05) stem/leave DM content to Brigadier, Barnapoli, Sovereign, KR7872, Invitation, Interval, Chico, Purple Top and Spitfire but higher (P<0.05) than the other cultivars. Interval had a similar (P>0.05) stem/leave DM production rate to KR7872, Spitfire, Barnapoli and KR6099 but higher (P<0.05) than the other cultivars. KR6099 had a similar (P>0.05) stem/leave DM production to Sovereign but higher (P<0.05) than the other cultivars.

- All plant fractions

KR6099, Invitation, Barnapoli, Sovereign, KR7872 and Interval had a similar (P>0.05) mean DM content to Chico, Spitfire and Brigadier but higher (P<0.05) than the other cultivars. Interval, KR7872 and Spitfire had a similar (P>0.05) mean DM production rate to Nooitgedacht, Barnapoli, KR6099, Invitation, Brigadier and Sovereign but higher (P<0.05) than the other cultivars. KR6099, Brigadier, Invitation and Sovereign had the highest (P<0.05) total DM production.

Table 4 indicates the dry matter (DM) production rate, DM content, DM production and days from plant to harvest of different plant fractions of annual fodder crop species planted during March 2012.

- Bulbs

Invitation and Brigadier had the highest (P<0.05) bulb DM content, the highest (P<0.05) bulb DM production rate and the highest (P<0.05) bulb DM production.

- Stems and leaves

Invitation had the highest (P<0.05) stem-leave DM content.Nooitgedacht, Purple Top and Dynamo had a similar (P>0.05) stem-leave DM production rate than Barkant but higher (P<0.05) than the other cultivars. Sovereign had a similar (P>0.05) DM production than KR6099 but higher (P<0.05) than the other cultivars.

- All plant fractions

Invitation had the highest (P<0.05) mean DM content. Dynamo and Nooitgedacht had a similar (P>0.05) mean DM production rate than Barkant but higher than the other cultivars. Brigadier had a similar (P>0.05) DM production than Invitation but higher (P<0.05) than the other cultivars.

Table 3: The dry matter (DM) production rate, DM content, DM production and days from plant to harvest of different plant fractions of annual Fodder crop species planted during January 2012 on the Outeniqua Research Farm near George.

Treatment	**Days from plant to harvest**	**Bulbs**			**Stems and leaves**			**All plant fractions**		
		DM production rate (Kg DM ha^{-1} day^{-1})	**DM content (%)**	**DM production (Kg DM ha^{-1})**	**DM production rate (Kg DM ha^{-1} day^{-1})**	**DM content (%)**	**DM production (Kg DM ha^{-1})**	**Mean DM production rate (Kg DM ha^{-1} day^{-1})**	**Mean DM content (%)**	**Total DM production (Kg DM ha^{-1})**
Dynamo	**75**	5.10^{b}	5.33^{c}	383^{b}	16.5^{e}	10.3^{bcd}	1234^{fg}	21.6^{de}	7.82^{cd}	1616^{fg}
Barkant	**75**	3.84^{b}	4.74^{c}	288^{b}	12.4^{e}	9.58^{cd}	929^{g}	16.2^{e}	7.16^{de}	1216^{g}
Green Globe*	**75**	.	.	.	.	.	.	.	.	.
KR7809	**75**	3.67^{b}	4.50^{c}	275^{b}	110^{e}	9.19^{d}	828^{g}	14.7^{e}	6.85^{de}	1103^{g}
Purple Top	**75**	1.93^{b}	6.34^{c}	145^{b}	12.4^{e}	10.5^{abcd}	932^{fg}	14.4^{e}	8.40^{de}	1077^{g}
T-Raptor	**75**	2.33^{b}	9.99^{b}	145^{b}	14.5^{e}	9.00^{d}	1091^{fg}	16.9^{e}	9.50^{bc}	1265^{g}
Barnapoli	**97**	.	.	.	41.6^{ab}	12.0^{ab}	4038^{d}	41.6^{ab}	12.0^{a}	4038^{cd}
KR7872	**97**	.	.	.	44.0^{ab}	11.7^{ab}	4264^{cd}	44.0^{a}	11.7^{a}	4264^{cd}
Interval	**97**	.	.	.	47.8^{a}	11.6^{ab}	4637^{cd}	47.8^{a}	11.6^{a}	4637^{c}
Spitfire	**97**	.	.	.	43.3^{ab}	10.7^{abcd}	4203^{d}	43.3^{a}	10.7^{ab}	4203^{cd}
Caledonian	**159**	.	.	.	32.7^{cd}	9.55^{cd}	5198^{bc}	32.7^{bc}	9.55^{bc}	5198^{bc}
KR6099	**159**	.	.	.	41.6^{ab}	12.4^{a}	6610^{a}	41.6^{ab}	12.4^{a}	6610^{a}
Sovereign	**159**	.	.	.	38.6^{bc}	11.7^{ab}	6137^{ab}	38.6^{ab}	11.7^{a}	6137^{ab}
Invitation	**159**	24.8^{a}	12.5^{a}	3944^{a}	15.5^{e}	11.6^{ab}	2460^{e}	40.3^{ab}	12.0^{a}	6404^{a}
Brigadier	**159**	28.4^{a}	9.08^{b}	4518^{a}	12.0^{e}	12.0^{ab}	1909^{ef}	40.4^{ab}	10.5^{ab}	6427^{a}
Nooitgedacht	**75**	4.32^{b}	5.14^{c}	324^{b}	37.6^{bc}	5.95^{e}	2821^{e}	41.9^{ab}	5.54^{e}	3145de
Chico	**97**	.	.	.	28.4^{d}	11.2^{abc}	2759^{e}	28.4^{cd}	11.2^{ab}	2759^{ef}
LSD (0.05)		**4.507**	**2.048**	**674.8**	**8.209**	**1.998**	**989.6**	**9.540**	**2.000**	**1174.4**

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

Table 4: The dry matter (DM) production rate, DM content, DM production and days from plant to harvest of different plant fractions of annual Fodder crop species planted during March 2012 on the Outeniqua Research Farm near George

Treatment	Days from plant to harvest	Bulbs			Stems and leaves			All plant fractions		
		DM production rate (Kg DM ha^{-1} day^{-1})	DM content (%)	DM production (Kg DM ha^{-1})	DM production rate (Kg DM ha^{-1} day^{-1})	DM content (%)	DM production (Kg DM ha^{-1})	Mean DM production rate (Kg DM ha^{-1} day^{-1})	Mean DM content (%)	Total DM production (Kg DM ha^{-1})
Dynamo	**64**	5.46^{b}	7.34^{c}	349^{b}	51.0^{ab}	7.76^{efg}	3262^{cd}	56.4^{ab}	7.55^{fgh}	36.11^{d}
Barkant	**64**	6.45^{b}	6.92^{c}	413^{b}	54.7^{a}	7.60^{efg}	3498^{cd}	61.1^{a}	7.26^{fgh}	3911^{cd}
Green Globe	**64**	.	.	.	.	.	.	.	.	.
KR7809	**64**	5.84^{b}	7.27^{c}	374^{b}	42.0^{bcd}	6.73^{gh}	2690de	47.9^{bcde}	7.00^{gh}	3065de
Purple Top	**64**	4.15^{b}	10.2^{b}	266^{b}	45.5^{abc}	6.35^{gh}	2912de	49.6^{bcd}	8.26^{efg}	3177de
T-Raptor	**64**	.	.	.	35.7^{cd}	7.62^{efg}	2282^{e}	35.7^{fg}	7.62^{fgh}	2282^{e}
Barnapoli	**93**	.	.	.	42.1^{bcd}	9.35^{cd}	3912^{c}	42.1^{defg}	9.35^{ef}	3912^{cd}
KR7872	**93**	.	.	.	42.1^{bcd}	8.34^{def}	3914^{c}	42.1^{defg}	8.34^{ef}	3914^{cd}
Interval	**93**	.	.	.	42.6^{bc}	8.34^{def}	3961^{bc}	42.6^{cdefg}	8.34^{ef}	3961^{cd}
Spitfire	**93**	.	.	.	37.7^{cd}	7.31^{fgh}	3505^{cd}	37.7^{efg}	7.31^{fgh}	3505^{d}
Caledonian	**148**	.	.	.	23.6^{ef}	10.1^{c}	3493^{cd}	23.6^{h}	10.1^{cd}	3493^{d}
KR6099	**148**	.	.	.	32.7^{de}	11.7^{b}	4839^{a}	32.7^{gh}	11.7^{b}	4839^{bc}
Sovereign	**148**	.	.	.	32.5^{de}	12.1^{b}	4806^{ab}	32.5^{gh}	12.1^{b}	4806^{bc}
Invitation	**148**	20.6^{a}	13.6^{a}	3049^{a}	22.9^{ef}	13.6^{a}	3390^{cd}	43.5^{cdef}	13.6^{a}	6439^{a}
Brigadier	**148**	18.4^{a}	13.4^{a}	2718^{a}	19.0^{fg}	8.99^{cde}	2812de	37.4^{efg}	11.2^{bc}	5530^{ab}
Nooitgedacht	**64**	3.11^{b}	7.02^{c}	199^{b}	49.6^{ab}	5.90^{h}	3177^{cd}	52.8^{abc}	6.46^{h}	3376^{d}
Chico	**93**	.	.	.	10.7^{g}	9.36^{cd}	994^{f}	10.7^{i}	9.36^{de}	994^{f}
LSD (0.05)		**3.574**	**1.513**	**486.5**	**9.89**	**1.430**	**858.6**	**10.54**	**1.297**	**970.2**

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

Conclusion

The forage turnip cultivar Dynamo, the forage rape cultivar Interval, the Kale cultivar KR6099, the Swede cultivar Invitation and the fodder radish cultivar Nooitgedacht were the most productive cultivars during the November planting date. The Kale cultivars KR6099 and Sovereign, the Swede cultivar Invitation and the fodder beet cultivar Brigadier were the most productive cultivars during the January planting date. The Swede cultivar Invitation and the fodder beet cultivar Brigadier was the most productive cultivars during the March planting date.

For the November, January and March planting dates, the Swede cultivar Invitation had the highest or similar to the highest bulb DM content, bulb DM production rate and bulb DM production. The Kale cultivar KR6099 had, for the November and January planting date, the highest or similar to the highest stem-leave DM content, stem-leave DM production rate and stem-leave DM production.

Message to the farmer

The selection of a species/cultivar by farmers should be based on specific seasonal feed shortages and fodder flow requirements within a pasture system.

References

Ayres L 2002. Forage brassicas – quality crops for livestock production. Agfact P2.1.13. NSW Agriculture. http://www.dpi.nsw.gov.au/data/assets/pdf_file/0003/146730/forage-brassi cas-quality-crops-for-livestock-prod uction.pdf Bartholomew HM and Underwood JF nd. Brassicas for forage. AGF-020-92. Ohio State University Extension. Available online at http://ohioline.osu.edu/agf-fact/ 0020.html [Visited on 12 November 2010]

Botha PR (2002). Die gebruik van vogspanningmeters vir besproeiing-skedulering by weidings. Weidingskursus 2002. Inligtingsbundel Suid-Kaap Land-bou-ontwikkelingsentrum. Departement Landbou Wes-Kaap. pp 141-149

Hall MH and Jung J 1994. Forage chicory. Agronomy facts 45. Penn State College of Agricultural Sciences. Available online at http://extension.psu.edu/cmeg/facts/agfact45.pdf

Hall MH and Jung J 2005. Use of brassica crops to extend the grazing season. Agronomy facts 33. Penn State College of Agricultural Sciences. http://cropsoil.psu.edu/extension/facts/agfact33.pdf [Visited on 8 November 2010]

Hogh-Jensen H. Nielsen B. Thamsborg SM 2006. Productivity and quality, competition and facilitation of chicory in ryegrass/legume-based pastures under various nitrogen supply levels. European Journal of Agronomy 24 (2006). Pp 248

Khogali ME. Dagash YMI. El-Hag MG 2011. Nitrogen fertilizer effects on quality of fodder beet (*Beta vulgaris* var. Crassa). Agriculture and Biology Journal of North America 2011. 2(2): 270

Krall, J.M., D.W. Koch, F.A. Gray, and L.M. Yun. 1996. Potential of sugar beet nematode-resistant radishes and mustard for use in sugar beet rotations. p. 619-622. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington

Kynoch Pasture Handbook 2004. Pp 236,

Ott RL 1998. An Introduction to Statistical methods and data analysis. Belmont, California: Duxbury Press: pp 807-837 (pp 1-1051)

Reid RL. Puoli JR. Jung GA, Cox-Ganser JM. McCoy A 1994. Evaluation of Brassicas in grazing systems for sheep I: Quality of forage and animal production. Journal of Animal Science 1994. 72: 1823.

SAS Institute, Inc. (2008), SAS Version 9.2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Shapiro SS and Wilk MB 1965. An Analysis of Variance Test for Normality. Biometrika, 52, 591-611.

Tainton NM 2000. Pasture Management in SA. Pp 171.

Turki IY. Khogali ME 2011. Effect of feeding fodder beet (*Beta vulgaris* L.var.Crassa) on fattening efficiency of Sudan dessert sheep. Advances in Environmental Biology, 5(7): 1593.

Wilson, D.R.; Zyskowski, R.F.; Maley, S.; Pearson, A.J. 2004. A potential yield model for forage brassicas. Proc. 4th International Crop Science Convention, September 2004, Brisbane, Australia. Pp 4

PRODUCTION OF SUB-TROPICAL GRASS SPECIES UNDER RAIN-FED CONDITIONS IN THE SOUTHERN CAPE OF SOUTH AFRICA

MM Lombard[1] and PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

Milk and beef producers are constantly searching for adapted cultivars to use in their production systems. These cultivars should be able to produce a sufficient amount of dry matter (DM) sustainably in the southern Cape of South Africa. Ryegrass (*Lolium perenne*), a cool season producer, kikuyu (*Pennisetum clandestinum*), a warm season producer, as well as a selection of legumes form the pasture base in the southern Cape.

Traditionally, other alternative warm season producing grasses are not cultivated in the southern Cape due to a lack of information on the production potential of these grasses in the area. These sub-tropical grasses include: Bottle brush grass (*Antephora pubescens), Common Signal grass (Brachiaria brizantha), Rhodes grass (Chloris gayana), Bermuda grass (Cynodon dactylon), Smuts Finger grass (Digitaria eriantha) Weeping Lovegrass (Eragrostis curvula), Buffalo grass (Panicum maximum)* and Common Ehrharta (*Ehrharta calycina)*.

Warm season producing grasses are adapted to warm humid areas receiving rain in the summer months (Donaldson, 2001). The southern Cape with its year round rainfall is not known for its grass planes (Chippendall & Meredith, 1955). Due to a change in climatic conditions it might be possible that some of these grass species is adapted to produce quality fodder under rain-fed conditions in the southern Cape.

A short summary focusing on a description of the considered species, requirements and uses thereof can be found in Table 1.

The aim of this study was to evaluate the production potential of 15 perennial sub-tropical grass cultivars in the southern Cape of South Africa.

Materials and methods

This study was carried out on the Outeniqua Research Farm near George (Altitude 201m, 33° 58' 38" South and 22° 25' 16" East, rainfall 728 mm per year) in the Western Cape province of South Africa and was executed under rain-fed conditions on a Witfontein soil form. Fertilizer was applied to raise the soil nutrient levels according to soil analysis recommendations.

Table 1 Description, soil and climate requirements, as well as application of the different summer grass species to be used in the trial on Outeniqua Research Farm

Species	Description	Soil and climate	Uses
Antephora pubescens	Perennial[1,2,3] Tufted[1,2,3] Creeping rhizomes[1,3] Height: 30-1000 mm[1] Palatable[2]	Soil: Widely adapted but prefers sandy soil[2] Area: Dry, warm[2] Rainfall: >350 mm[2]	Foggage[2]
Brachiaria brizantha	Perennial[1] Robust[1] Height: max 2000 mm[1]	Soil: Adapted to most soil types[4]	Fodder[1] Grazing[4]
Chloris gayana	Perennial[1,3] Tufted with stolons[1,2,3]	Soil: Adapted to most soil types[2] Area: Sub-tropical to temperate; low rainfall[2]	Pasture[1,2] Hay[1]
Cynodon dactylon	Perennial[1,3] Creeping rhizomes and stolons[1,3]	Soil: High fertility[2] Area: Warm[2] Rainfall: >500 mm[2]	Pasture[2] Hay[2] Pioneer – erosion control[1]
Digitaria eriantha	Perennial[1,2,3] Tufted[1,2,3] Creeping rhizomes[1] Height: 300-900 mm[1]	Soil: Adapted to most soil types[2,3] Rainfall: >500 mm[2]	Foggage[2] Fodder[1] Hay[2]
Eragrostis curvula	Perennial[1,2,3] Tufted[1,2,3] Height: 300-1200 mm[1]	Soil: Widely adapted put prefers acidic sandy soil[2, 3] Rainfall: >650 mm[2]	Fodder[1] Pasture[2] Hay[2] Ley[1]
Panicum maximum	Perennial[1,3] Tufted[1,3] Creeping rhizomes[1,3] Height: 600-2000 mm[1]	Soil: Adapted to most soil types[3] Area: Tropical and sub-tropical[3] Rainfall: >625 mm[3]	Foggage[3] Pasture[1,3] Hay[1,3] Silage[3]
Ehrharta calycina	Perennial[1] Creeping rhizomes[1] Height: 300-700 mm[1]		Pasture[1]

[1]Chippendall & Meredith, 1955

[2]Kynoch Pasture Handbook, 2004

[3]Donaldson, 2001

[4]Tropical Forages, no date

The trial was planted on the 17th of March 2010. Lands were sprayed with glyphosate three weeks before planting. Nitrogen (N) and phosphate (P) was applied at 60 kg ha^{-1} and 20 kg ha^{-1} respectively before cultivation. Soil was scarified, tilled with a harrow disk and konskilde to create a seedbed, mix the fertilizer with the soil and to remove dead plant litter. Seed was planted in 30cm rows, after which the plots were rolled with a land roller.

Grasses were given sufficient time to establish. Sampling only commenced if 90% of the treatments have emerged and established. The trial was cut down during October 2010 as part of weed control and the first harvest of the trial took place during January 2011 (the summer harvest), three months later.

Plots were sampled when 60% of the trial reaches the stage where it was suitable as foggage. A strip of pasture, 1.23m x 4.8m was cut with a cutter bar mower to a height of 100mm and used for pasture sampling. The weight of the cut strip was determined, after which approximately 500g of the sample was placed in a brown paper bag and weighed wet and dry to determine DM content. Samples were dried in an oven at 60°C for 72 hours to determine dry weight. Plots received post-harvest N and potassium (K) fertilizer at 60 kg N ha^{-1} and 20 kg K per 1 ton DM produced ha^{-1}. The trial was managed as foggage and sampled on a 90 day cycle.

Table 2: Different perennial summer grasses and cultivars, with prescribed seeding rates, used in the trial at Outeniqua Research Farm

Species	**Common name**	**Cultivar**	**Seeding rate (kg ha^{-1})***
Antephora pubescens	Bottle Brush Grass / Wool Grass	Wollie	5
Brachiaria brizantha	Common Signal Grass	Brachiaria	4
Chloris gayana	Rhodes Grass	Katambora	5
Chloris gayana	Rhodes Grass	Katambora#	27.5
Cynodon dactylon	Bermuda Grass / Couch Grass	Bermuda	6
Cynodon dactylon	Bermuda Grass / Couch Grass	Vaquero	6
Digitaria eriantha	Smuts Finger Grass	Irene	3
Digitaria eriantha	Smuts Finger Grass	Irene#	7
Eragrostis curvula	Weeping Lovegrass	PUK E436	2
Eragrostis curvula	Weeping Lovegrass	Ermelo#	3
Eragrostis curvula	Weeping Lovegrass	Agpal	2
Eragrostis curvula	Weeping Lovegrass	Ermelo	2
Panicum maximum	Buffalo Grass	Gatton	4
Panicum maximum	Buffalo Grass	PUK 8	4
Ehrharta calycina	Common Ehrharta	Mission	3

*The seeding rates used are as prescribed by Agricol (2007).

#Pelleted seeds

The experimental design was a randomized block design with 15 treatments randomly allocated in 3 blocks. An appropriate analysis of variance was performed, the assumption of normality of the residuals tested to ensure valid and reliable results (Shapiro & Wilk, 1965). A Student LSD (least significant difference) at 5 % significance level was done to compare the treatment means (Ott,1998). The STATS module of SAS version 9.2 was used to analyze the data (SAS Institute, Inc., 2008).

Results and discussion

Table 3 indicates the seasonal DM content of perennial sub-tropical grass cultivars evaluated for the period summer 2010 to spring 2011. The cultivar Ermelo (pelleted) had a similar summer (P>0.05) DM content than Ermelo but higher (P<0.05) than all the other cultivars. The cultivars Ermelo and Ermelo (pelleted) had a similar autumn (P>0.05) DM content than Agpal, PUK E436 and Wollie but higher (P<0.05) than the other cultivars. The cultivars Agpal, Ermelo (pelleted) and Ermelo had the highest winter (P<0.05) DM content. The cultivars Ermelo (pelleted) and Ermelo had the highest spring (P<0.05) DM content.

Table 3: The seasonal and mean dry matter content for the period summer 2010 to spring 2011, of perennial sub-tropical grass cultivars evaluated under rain fed conditions

Cultivars	Summer	Autumn	Winter	Spring
Wollie	0.00^{g}	42.31^{abcd}	0.00^{f}	0.00^{g}
Brachiaria	21.74^{de}	25.57^{e}	28.14^{cd}	31.38^{f}
Katambora	20.25^{ef}	31.00^{cde}	27.41^{cd}	24.20^{de}
Katambora#	24.11^{de}	31.04^{cde}	28.80^{c}	23.94^{de}
Bermuda	22.97^{de}	30.36^{cde}	0.00^{f}	0.00^{g}
Vaquero	16.85^{f}	27.79^{de}	0.00^{f}	0.00^{g}
Irene	25.20^{d}	34.09^{bcde}	26.94^{cd}	25.71^{d}
Irene#	25.92^{d}	32.87^{bcde}	27.80^{cd}	25.56^{d}
PUK E436	37.51^{b}	45.70^{abc}	33.74^{b}	37.68^{b}
Ermelo#	43.18^{a}	50.19^{a}	40.14^{a}	41.70^{a}
Agpal	35.91^{bc}	48.09^{ab}	43.04^{a}	38.00^{b}
Ermelo	39.64^{ab}	50.34^{a}	40.05^{a}	40.12^{a}
Gatton	23.42^{de}	29.34^{de}	25.06^{de}	22.05^{f}
PUK 8	22.89^{de}	30.80^{cde}	26.45^{cde}	22.84^{ef}
Mission	32.20^{c}	30.48^{cde}	23.58^{e}	29.76^{c}
***LSD (0.05)[1]**	4.245	15.715	3.353	1.859
****LSD (0.05)[2]**	8.066			

[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

Table 4 indicates the seasonal DM production rate of perennial sub-tropical grass cultivars evaluated for the period summer 2010 to spring 2011. The cultivars Katambora and Katambora (pelleted) had a similar summer (P>0.05) DM production rate than PUK E436 and Ermelo (pelleted), but higher (P<0.05) than the other cultivars. Katambora and Katambora (pelleted) had a similar autumn (P>0.05) DM production rate than Brachiaria, but higher (P<0.05) than the other cultivars. The cultivar Mission had the highest winter (P<0.05) DM production rate. The cultivars Irene (pelleted), Irene and Ermelo (pelleted) had a similar spring (P>0.05) DM production rate than Ermelo, Katambora (pelleted) and PUK E436 but higher (P<0.05) than the other cultivars.

Table 4: The seasonal and mean matter production rate for the period summer 2010 to spring 2011, of perennial sub-tropical grass cultivars evaluated under rain fed conditions

Cultivars	**Summer**	**Autumn**	**Winter**	**Spring**
Wollie	0.00^{f}	1.41^{f}	0.00^{f}	0.00^{f}
Brachiaria	22.56^{cde}	54.74^{ab}	2.65^{ef}	19.60^{e}
Katambora	49.88^{a}	62.74^{a}	8.72^{cd}	44.33^{bc}
Katambora#	49.27^{a}	65.41^{a}	11.03^{c}	55.42^{ab}
Bermuda	0.45^{f}	2.54^{f}	0.00^{f}	0.00^{f}
Vaquero	0.10^{f}	1.00^{f}	0.00^{f}	0.00^{f}
Irene	14.79^{ef}	32.74^{de}	1.77^{f}	62.07^{a}
Irene#	16.21^{def}	35.25^{de}	1.49^{f}	67.58^{a}
PUK E436	40.80^{ab}	43.60^{cd}	24.79^{b}	54.47^{ab}
Ermelo#	38.06^{abc}	37.63^{de}	9.14^{cd}	61.30^{a}
Agpal	22.05^{cde}	26.96^{e}	6.55^{de}	37.51^{cd}
Ermelo	30.49^{bcde}	37.30^{de}	10.89^{c}	55.45^{ab}
Gatton	29.85^{bcde}	49.07^{bc}	9.77^{cd}	44.27^{bc}
PUK 8	17.94^{de}	51.14^{bc}	9.71^{cd}	37.60^{cd}
Mission	32.18^{bcd}	6.53^{f}	39.98^{a}	23.89^{de}
***LSD (0.05)[1]**	16.773	11.037	4.329	13.744
****LSD(0.05)[2]**	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

Table 5 indicates the seasonal and annual total dry matter production of perennial sub-tropical grass cultivars evaluated for the period summer 2010 to spring 2011. The cultivars Katambora and Katambora (pelleted) had a similar summer (P>0.05) DM production than PUK E436 and Ermelo (pelleted), but higher (P<0.05) than the other cultivars. Katambora and Katambora (pelleted) had a similar autumn (P>0.05) DM production than Brachiaria, but higher (P<0.05) than all the other cultivars. The cultivar Mission had the highest winter (P<0.05) DM production. The cultivars Irene (pelleted), Irene and Ermelo (pelleted) had a similar spring (P>0.05) DM production than Ermelo, Katambora (pelleted) and PUK E436 but higher (P<0.05) than the other cultivars. The cultivar Katambora (pelleted) had a similar total annual (P>0.05) DM production than PUK E436 and Katambora but higher (P<0.05) than the other cultivars.

Table 5: The seasonal and total dry matter production for the period summer 2010 to spring 2011, of perennial sub-tropical grass cultivars evaluated under rain fed conditions

Cultivars	**Summer**	**Autumn**	**Winter**	**Spring**	**Total DM production (kg DM ha^{-1})**
Wollie	0^{f}	152^{f}	0^{f}	0^{f}	152^{g}
Brachiaria	2075^{cde}	5912^{ab}	403^{ef}	1647^{e}	10037^{ef}
Katambora	4589^{a}	6776^{a}	1326^{cd}	3724^{bc}	16412^{abc}
Katambora#	4533^{a}	7064^{a}	1677^{c}	4655^{ab}	17929^{a}
Bermuda	42^{f}	274^{f}	0^{f}	0^{f}	315^{g}
Vaquero	9^{f}	108^{f}	0^{f}	0^{f}	114^{g}
Irene	1360^{ef}	3536^{de}	270^{f}	5214^{a}	10380^{ef}
Irene#	1492^{def}	3807^{de}	227^{f}	5677^{a}	11202^{def}
PUK E436	3753^{ab}	4709^{cd}	3768^{b}	4576^{ab}	16806^{ab}
Ermelo#	3501^{abc}	4064^{de}	1390^{cd}	5149^{a}	14104^{bcd}
Agpal	2028^{cde}	2912^{e}	996^{de}	3151^{cd}	9087^{f}
Ermelo	2805^{bcde}	4029^{de}	1656^{c}	4658^{ab}	13147^{cde}
Gatton	2746^{bcde}	5299^{bc}	1486^{cd}	3719^{bc}	13250^{cde}
PUK 8	1623^{de}	5523^{bc}	1475^{cd}	3159^{cd}	11779^{def}
Mission	2960^{bcd}	705^{f}	6078^{a}	2007^{de}	11749^{def}
***LSD (0.05)^{1}**	1543.0	1191.8	657.9	1154.5	3270.8
****LSD(0.05)^{2}**	1048.8				

^{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

The Rhodes grass cultivars Katambora and Katambora (pelleted) and the Weeping Lovegrass cultivar PUK E436 was the most productive cultivars. The Weeping Lovegrass cultivars Ermelo and Ermelo (pelleted) had the highest or similar to the highest DM content over all four seasons.

Message to the farmer

The selection of a species/cultivar by farmers should be based on specific seasonal feed shortages and fodder flow requirements within a pasture system.

References

Agricol 2007. Product Guide. Available online at:

http://www.agricol.co.za/perennial_summer_grasses.pdf [Visited on 21 January 2010]

Chippendall LKA and Meredith D 1955. *The grasses and pastures of South Africa*. pp 42, 43, 142, 145, 197, 200, 329, 330, 371, 372, 403, 436, 451, 542.

Kynoch Pasture Handbook 2004. pp 19, 20, 21, 22,

Ott, R.L. (1998) An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051)

SAS Institute, Inc. (2008), SAS Version 9.2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Shapiro, S. S. and Wilk, M. B. (1965) ; An Analysis of Variance Test for Normality (complete samples)., Biometrika, 52, 591-611.

Tropical forages n.d. Brachiaria brizantha. Available online at:

http://www.tropicalforages.info/key/Forages/Media/Html/Brachiaria_brizantha.htm [Visited on 28 September 2009]

THE PRODUCTION POTENTIAL OF FESCUE, *FESTULOLIUM* HYBRIDS AND RYEGRASS CULTIVARS IN THE SOUTHERN CAPE

J van der Colf[1] & PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

A call for forage cultivars with increased resistance to biotic stresses and abiotic stresses such as heat, drought and cold due to climate change, has recently been identified (Kopecky et al. 2005). The complementary agronomic characteristics of ryegrass (*Lolium* spp.) and Fescues (*Festuca* spp.), namely high forage quality and stress tolerance respectively, has led to various attempts to combine these characteristics through hybridisation of these species (Kopecky et al. 2005, Akgun et al. 2008). The resultant hybrids are commonly referred to as *Festulolium*X spp. So far 23 amphidiploid Festulolium cultivars have been registered internationally, with an additional 18 cultivars resulting from introgression of tall fescue and perennial or Italian ryegrass also available (Ghesquire et al. 2010).

Three different hybrid varieties are commonly available. *Festulolium pabulare* is a cross between Tall Fescue (*Festuca arundinacea*) and Italian ryegrass (*Lolium multiflorum* var. *italicum*) and *Festulolium braunii* is a cross between Meadow Fescue (*Festuca pratensis*) and Italian ryegrass. Both these crosses are then back-crossed with either their fescue or ryegrass parent species to obtain, respectively, festucoid and loloid varieties.

There is currently no scientific data describing the production potential of such Festulolium varieties compared to that of ryegrass and fescue under irrigation in the Southern Cape. The aim of this study was to determine and compare the production potential of various Festulolium cultivars relative to that of ryegrass and fescue. Thirteen Festulolium cultivars, 7 fescue cultivars and 4 ryegrass cultivars were compared in terms of seasonal and annual dry matter (DM) production over a three year period. The trial was established during May 2011 and this paper will discuss the first year of data.

Materials and methods

The study was carried out on the Outeniqua Research Farm near George (Altitude 201 m, 33° 58' 38" S and 22° 25' 16" E, rainfall 728 mm year^{-1}) in the Western Cape of South Africa on an Estcourt Soil type (Soil Classification Workgroup, 1991). The study area was under permanent overhead sprinkler irrigation, with irrigation scheduling undertaken by means of a tensiometer. Irrigation commenced at a tensiometer reading of -25 kPa and was terminated at a reading of -10 kPa (Botha 2002).

Prior to establishment soil samples were taken to a depth of 150mm and analysed for Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S, and C levels. Fertiliser was applied according to the soil analysis to raise soil P level to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and pH (KCl) to 5.5 (Beyers 1973).

The scientific name, *Festuca* parent, *Lolium* parent, Backcross species and cultivar name of species that were evaluated are shown in Table 1. A total of 24 cultivars are being evaluated in the form of a randomized design, with three replicates per cultivar (total of 72 plots).

The trial was established on 11 May 2011 on a paddock previously planted to perennial ryegrass-clover pastures. The paddock was sprayed with a contact herbicide during January and tilled during February to remove the existing sward. Monthly herbicide applications (up to establishment) were aimed at eradication of emerging weeds. The trial area was tilled prior to establishment with a disk harrow and kongskilde and rolled with a light landroller to create a firm seedbed and eradicate any remaining weeds. The various cultivars/species were planted according to commercially recommended seeding rates for fescue (20kg ha^{-1}), Italian ryegrass (25 kg ha^{-1}) and perennial ryegrass (20 kg ha^{-1}). The Festuloliums were planted at 20 kg ha^{-1}. Plots were 2.1 m x 6 m per treatment (12.6 m^2), with 14 rows spaced 15 cm apart. After establishment plots were raked lightly to cover seeds.

Plots were harvested every 28 days to determine growth rate (kg DM ha^{-1} day^{-1}) and total DM production (kg DM ha^{-1}) by means of quadrats. Three quadrats of 0.25 m^2 were randomly placed per plot and cut to a height of 50 mm. The samples were pooled and weighed. A grab sample of approximately 400g was taken from the pooled sample, weighed, dried at 60°C for 72 hours and re-weighed to determine DM content. After sampling plots are cut to a uniform height of 50 mm using a Honda Lawnmower. All plots receive a topdressing of 50 kg N ha^{-1} and 50 kg K ha^{-1} after each harvest (ARC, 2005). Plots are sprayed with herbicide when required to control weeds.

A Student least significant difference (LSD) test at 5 % significance level was preformed to compare the treatment means (Ott 1998). The STATS module of SAS version 9.2 (2008) was used to analyze the data. Data was analyzed in the following manner:

- The mean growth rates, seasonal DM production and annual DM production of the different species compared with each other.
- All cultivars compared with each other.
- Festulolium cultivars compared with each other.

The production potential of Festulolium cultivars will be discussesd in general and in comparison with the parent lines (i.e. fescue and ryegrass species used in crosses) and the commonly used perennial grass species in the area, perennial ryegrass.

Table 1: The scientific name, *Festuca* parent, *Lolium* parent, back-cross species and cultivar name of species being evaluated during the study

	Scientific name	*Festuca* parent	*Lolium* parent	Back-cross species	Cultivar
1	*F. arundinacea*	-	-	-	Kora
2	*F. arundinacea*	-	-	-	Tuscany
3	*F. arundinacea*	-	-	-	Baroptima
4	*F. arundinacea*	-	-	-	Verdant
5	*F. arundinacea*	-	-	-	Jenna
6	*F. pratensis*	-	-	-	Laura
7	*F. pratensis*	-	-	-	Jamaica
8	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*F. arundinacea*	Felina
9	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*F. arundinacea*	Hykor
10	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*F. arundinacea*	Mahulena
11	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*F. arundinacea*	Rebab
12	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*F. arundinacea*	HZFLPC2
13	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*F. arundinacea*	Fojtan
14	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*L. multiflorum*	Becva
15	*Fest. pabulare*	*F. arundinacea*	*L. multiflorum*	*L. multiflorum*	Lofa
16	*Fest. braunii*	*F. pratensis*	*L. multiflorum*	*L. multiflorum*	Perun
17	*Fest. braunii*	*F. pratensis*	*L. multiflorum*	*L. multiflorum*	Perseus
18	*Fest. braunii*	*F. pratensis*	*L. multiflorum*	*L. multiflorum*	Hostyn
19	*Fest. braunii*	*F. pratensis*	*L. multiflorum*	*L. multiflorum*	Paulita
20	*Fest. braunii*	*F. pratensis*	*L. multiflorum*	*L. multiflorum*	Achilles
21	*L. perenne*	-	-	-	Bealy
22	*L. perenne*	-	-	-	Bronsyn
23	*L. multiflorum*	-	-	-	Jeanne
24	*L. multiflorum*	-	-	-	Parfait

Results and discussion

Species compared

The mean monthly growth rate (kg DM ha^{-1}) of tall fescue, meadow fescue, perennial ryegrass, Italian ryegrass and Festulolium cultivars is shown in Table 2. The highest ($P<0.05$) growth rate was obtained by different species during different months. Perennial ryegrass had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate during all the months except January and April.

The total seasonal and annual dry matter production (kg DM ha^{-1}) of tall fescue, meadow fescue, perennial ryegrass, Italian ryegrass and Festulolium cultivars is shown in Table 3. The highest (P<0.05) total annual DM production was achieved by Italian and perennial ryegrass, with a similar (P>0.05) production obtained by *Festulolium braunii*. The total annual DM production of tall fescue and meadow fescue did not differ (P>0.05).

The production potential of the different festulolium varieites will now be discussed relative to that of the parent species (*Festuca* spp. and *Lolium* spp.):

a) ***Festulolium pabulare loloid: Tall Fescue x Italian ryegrass x Italian ryegrass***

Festulolium pabulare loloid (FPL) had a similar (P>0.05) growth rate to Italian ryegrass from establishment to April, but its growth rate was lower (P<0.05) during May (Table 2). As result, the seasonal DM production of FPL was similar (P>0.05) to that of Italian ryegrass during all seasons. Irrespective of this, the annual DM production of FPL was lower (P<0.05) than for Italian ryegrass (Table 3).

From establishment until October the growth rate of FPL was higher (P<0.05) than or similar (P>0.05) to that of tall fescue, while from November until May the growth rate of FPL was similar (P>0.05) to or lower (P<0.05) than that of tall fescue. The seasonal dry matter production of FPL was higher (P<0.05) than that of tall fescue during winter, but lower (P<0.05) during summer and autumn. The total annual DM production of fescue and FPF was similar (P>0.05).

Festulolium pabulare loloid had the potential to match the growth rate of Italian ryegrass during the majority of the growth season and have a higher growth rate during early establishment than tall fescue.

b) Festulolium pabulare festucoid: Tall Fescue x Italian ryegrass x Italian ryegrass

The growth rate of *Festulolium pabulare* festucoid (FPF) was similar (P>0.05) to or higher (P<0.05) than that of tall fescue during all months except August. The seasonal dry matter production of tall fescue and FPF was similar (P>0.05) during all seasons except winter when the DM production of FPF had was lower (P<0.05). The total annual DM prodction of FPF and tall fescue was similar (P>0.05).

The growth rate of Italian ryegrass was higher (P<0.05) than for FPF from July to August, but lower (P<0.05) than or similar (P>0.05) to FPF from November to May. During winter and spring the total seasonal DM production of Italian ryegrass was (P<0.05) higher than that of FPF, with the annual DM production of Italian ryegrass also higher (P<0.05).

The annual production potential of FPL (P<0.05) was lower than that of Italian ryegrass but similar (P>0.05) to that of tall fescue. Thus, FPF, like tall fescue is slower to establish than ryegrass.

c) Festulolium braunii loloid: Meadow Fescue x Italian ryegrass x Italian ryegrass

The growth rate of *Festulolium braunii* loloid (FBL) was similar (P>0.05) to or higher (P<0.05) than that of meadow fescue during all months. The seasonal dry matter production of FBL was higher (P<0.05) than meadow fescue during winter and autumn and similar (P>0.05) during spring and summer. The annual DM production FBL was higher (P<0.05) than for meadow fescue.

Table 2: Mean monthly growth rate (kg DM ha^{-1} day^{-1})of tall fescue, meadow fescue, perennial ryegrass, Italian ryegrass and Festulolium varieties during year 1

Species	July*	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
TF	9.52^{cd}	42.0^{b}	75.4^{cd}	68.6^{c}	34.3^{ab}	62.0^{bc}	56.0^{ab}	17.1^{b}	50.2^{a}	43.0^{a}	29.3^{ab}
MF	5.45^{d}	48.8^{ab}	83.8^{bc}	73.0^{bc}	26.8^{bc}	58.6^{bc}	52.6^{abc}	14.1^{bc}	31.9^{c}	40.4^{ab}	26.7^{b}
IR	21.3^{a}	49.3^{ab}	100^{a}	78.6^{ab}	21.9^{cd}	60.2^{bc}	36.9^{d}	15.4^{c}	46.4^{b}	36.1^{ab}	34.0^{a}
PR	15.8^{ab}	55.3^{a}	92.4^{ab}	83.3^{a}	29.9^{abc}	74.9^{a}	43.1^{bcd}	18.3^{ab}	44.9^{ab}	34.1^{b}	29.4^{ab}
FPL	15.6^{ab}	47.0^{ab}	98.8^{a}	74.7^{abc}	16.6^{d}	51.7^{c}	43.3^{bcd}	9.05^{c}	37.7^{bc}	37.8^{ab}	27.1^{b}
FPF	4.72^{d}	32.6^{c}	64.1^{d}	72.1^{bc}	38.6^{a}	60.6^{bc}	61.1^{a}	23.5^{a}	49.4^{a}	39.1^{ab}	27.8^{ab}
FBL	14.3^{bc}	48.8^{ab}	89.3^{abc}	82.3^{a}	23.4^{cd}	62.7^{b}	40.6^{cd}	17.1^{ab}	46.6^{ab}	37.5^{ab}	31.1^{ab}
LSD	5.842	8.628	14.01	9.070	9.468	10.63	13.62	6.421	9.702	7.874	6.462

LSD (0.05) compares within month.

^{abc}Means with no common superscript differ significantly

TF: Tall fescue, MF: Meadow fescue, FPF: *Festulolium pabulare* festucoid (Tall fescue x Italian ryegrass x Tall fescue), FPL: *Festulolium pabulare* loloid (Tall fescue x Italian ryegrass x Italian ryegrass), FBL: *Festulolium braunii* loloid (Meadow fescue x Italian ryegrass x Italian ryegrass), PR: Perennial ryegrass, IR: Italian ryegrass

Table 3: Total seasonal and annual dry matter production (kg DM ha^{-1}) of tall fescue, meadow fescue, perennial ryegrass, Italian ryegrass and Festulolium varieties during year 1

Species	Winter	Spring	Summer	Autumn	Annual
TF	2405^{cd}	4965^{cd}	3845^{ab}	3437^{a}	14652^{bc}
MF	2193^{de}	5121^{bcd}	3566^{abc}	2761^{c}	13642^{c}
IR	3908^{a}	5618^{ab}	3210^{cd}	3247^{ab}	16010^{a}
PR	3512^{ab}	5738^{a}	3891^{ab}	3048^{abc}	16188^{a}
FPL	3216^{ab}	5441^{abc}	2966^{d}	2871^{bc}	14384^{bc}
FPF	1441^{e}	4847^{d}	4128^{a}	3267^{ab}	13683^{c}
FBL	3141^{bc}	5331^{abcd}	3434^{bcd}	3235^{ab}	15251^{ab}
LSD (0.05)	762.4	509.5	582.2	436.5	1057

LSD (0.05) compares within season.

^{abc}Means with no common superscript differ significantly

TF: Tall fescue, MF: Meadow fescue, FPF: *Festulolium pabulare* festucoid (Tall fescue x Italian ryegrass x Tall fescue), FPL: *Festulolium pabulare* loloid (Tall fescue x Italian ryegrass x Italian ryegrass), FBL: *Festulolium braunii* loloid (Meadow fescue x Italian ryegrass x Italian ryegrass), PR: Perennial ryegrass, IR: Italian ryegrass

Festulolium braunii loloid (FBL) had a similar (P>0.05) growth rate to Italian ryegrass during all months except July and February, when that of Italian ryegrass was higher (P<0.05). The seasonal dry matter production of FBL was similar (P>0.05) to that of Italian ryegrass during spring, summer and autumn, but lower (P<0.05) during winter. The total annual dry matter production of FBL and italian ryegrass was similar (P>0.05).

The FBL variety had a higher growth during establsihment than meadow fescue and similar growth rate to ryegrass from spring to autumn, making it quicker to establish than fescue, but slightly slower than Italian ryegrass.

Both *Festulolium pabulare* varieties had a similar (P>0.05) annual production potential to their fescue parent (tall fescue), but lower (P<0.05) than that of Italian ryegrass (Table 3). Festulolium braunii had a higher production potential than its fescue parent (meadow fescue) and similar to Italian ryegrass. Of the Festulolium varieties FBL had the highest total annual DM production, with a similar (P>0.05) production obtained by FPL.

Festulolium cultivars compared

The mean monthly growth rate of the Festulolium cultivars evaluated is shown in Table 4. The cultivar with the highest growth rate varied between months. The FPL cultivar Perun and FBL cultivars Becva, had the highest (P<0.05) or similar (P>0.05) to the highest growth rate from July to October. The FPF cultivar Mahulena had the highest (P<0.05) or similar (P>0.05) to the highest growth rate from October to May.

The total seasonal and annual DM production of the Festulolium cultivars evaluated is shown in Table 5. The FPL cultivar Becva and FBL cultivar Hostyn had similar (P>0.05) DM production to the highest producing cultivars during all seasons. The highest (P<0.05) total annual DM production was for the FBL cultivars Perun and Hostyn, with similar productions (P>0.05) obtained by the FPF cultivar Mahulena, FPL cultivar Becva and FBL cultivars Paulita and Achilles.

All cultivars compared

The mean monthly growth rate of fescue, Festulolium and ryegrass cultivars evaluated during the study is shown in Table 6. The highest monthly growth rate was obtained by different cultivars during the various months.

The total seasonal and annual DM production of fescue, Festulolium and ryegrass cultivars is shown in Table 7. The annual DM production of the perennial ryegrass cultivar Bealy was similar (P>0.05) to that of the Tall Fescue cultivar Verdant, but higher (P<0.05) than the rest. Verdant had the highest (P<0.05) seasonal DM production during winter. From spring to autumn the tall fescue cultivar Jenna, perennial ryegrass cultivar Bealy and festulolium cultivars Mahulena, Hostyn, and Paulita had the highest (P<0.05) or similar (P>0.05) to the highest seasonal DM production.

a) Festulolium cultivars compared to Italian ryegrass

The Italian ryegrass cultivars, Parfait and Jeanne did not differ in terms of total annual DM production. Parfait will be used to compare the seasonal and annual dry matter production of Festulolium cultivars to that of a the ryegrass parent. Parfait had a similar (P>0.05) total annual dry matter production to the cultivars Becva, Perun, Hostyn and

Table 4: The mean monthly growth rates (kg DM ha^{-1} day^{-1}) of festulolium cultivars during year 1

Species	**Cultivar**	**July[4]**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
FPF[1]	Felina	1.52^{e}	25.8^{d}	49.8^{g}	69.9^{bc}	36.3^{abcd}	62.7^{abc}	60.9^{abc}	17.1^{de}	48.0^{a}	35.7^{a}	22.9^{b}
FPF	Hykor	8.15^{cde}	32.9^{bcd}	70.8^{cdef}	78.7^{abc}	27.8^{bcde}	66.8^{ab}	53.4^{abcd}	16.5^{de}	52.1^{a}	35.5^{a}	27.8^{ab}
FPF	Mahulena	3.7^{e}	41.6^{abc}	72.0^{cdef}	73.3^{abc}	43.3^{a}	60.5^{abc}	64.5^{ab}	26.8^{abc}	46.7^{a}	40.9^{a}	34.8^{a}
FPF	Rebab	3.06^{e}	31.2^{cd}	59.5^{fg}	68.7^{bc}	44.7^{a}	64.2^{ab}	52.6^{abcd}	31.1^{a}	50.5^{a}	43.3^{a}	31.9^{ab}
FPF	HZFLPC2	3.83^{e}	30.7^{cd}	68.4^{defg}	68.2^{c}	40.6^{ab}	57.8^{abc}	72.7^{a}	21.7^{bcd}	51.6^{a}	36.1^{a}	23.4^{b}
FPF	Fojtan	6.26^{de}	33.6^{bcd}	64.1^{efg}	73.6^{abc}	38.9^{abc}	51.9^{bc}	62.8^{ab}	27.9^{ab}	50.4^{a}	43.1^{a}	26.2^{ab}
FPL[2]	Lofa	11.5^{cd}	45.7^{a}	83.1^{bcde}	81.3^{abc}	19.2^{e}	46.5^{c}	36.2^{cd}	7.9^{f}	33.7^{a}	35.8^{a}	26.2^{ab}
FPL	Becva	19.6^{ab}	48.3^{a}	114^{a}	68.1^{c}	14.1^{e}	57.0^{abc}	50.3^{abcd}	10.2^{ef}	41.6^{a}	39.8^{a}	28.0^{ab}
FBL[3]	Perun	20.7^{a}	47.2^{a}	98.9^{ab}	79.9^{abc}	24.6^{de}	57.6^{abc}	32.2^{d}	14.6^{def}	48.3^{a}	40.3^{a}	32.4^{ab}
FBL	Perseus	11.7^{cd}	43.7^{ab}	88.1^{bcd}	84.3^{ab}	23.4^{de}	63.5^{ab}	35.5^{cd}	14.1^{def}	39.1^{a}	36.8^{a}	32.4^{ab}
FBL	Hostyn	15.2^{abc}	50.1^{a}	88.5^{bc}	81.2^{abc}	22.2^{e}	72.3^{a}	46.4^{bcd}	19.2^{cd}	48.4^{a}	41.0^{a}	35.1^{a}
FBL	Paulita	12.4^{bcd}	49.9^{a}	84.6^{bcd}	86.5^{a}	25.7^{cde}	66.2^{ab}	45.5^{bcd}	21.6^{bcd}	52.4^{a}	33.2^{a}	31.6^{ab}
FBL	Achilles	11.5^{cd}	53.2^{a}	86.3^{bcd}	79.6^{abc}	20.9^{e}	54.0^{bc}	443.5^{bcd}	16.1^{de}	44.9^{a}	36.2^{a}	23.9^{b}
		7.692	11.65	19.95	16.01	13.86	16.7	25.88	8.042	19.65	14.76	10.03

[1]FPF: *Festulolium pabulare* festucoid (Tall fescue x Italian ryegrass x Tall fescue)

[2] FPL: *Festulolium pabulare* loloid (Tall fescue x Italian ryegrass x Italian ryegrass)

[3] FBL: *Festulolium braunii* loloid (Meadow fescue x Italian ryegrass x Italian ryegrass)

[4] Growth rate from establishment in May to first harvest

LSD (0.05) compares over cultivars within month

[abc]Means with no common superscript differ significantly

Table 5. Total seasonal and annual dry matter production (kg DM ha^{-1}) of festulolium cultivars during year 1

Species	Cultivar	Winter	Spring	Summer	Autumn	Annual
FPF[1]	Felina	960^{f}	4312^{c}	4002^{ab}	2911^{ab}	12185^{e}
FPF	Hykor	1957de	4927^{abc}	3893^{abc}	3248^{ab}	14025^{bcd}
FPF	Mahulena	1505^{ef}	5235^{ab}	4309^{a}	3434^{ab}	14483^{abcd}
FPF	Rebab	1247^{ef}	4787^{bc}	4205^{ab}	3526^{a}	13764de
FPF	HZFLPC2	1425^{ef}	4923^{abc}	4317^{a}	3124^{ab}	13788de
FPF	Fojtan	1554^{ef}	4900^{abc}	4044^{ab}	3359^{ab}	13856^{cde}
FPL[2]	Lofa	2744^{cd}	5123^{abc}	2583^{d}	2679^{b}	13129de
FPL	Becva	3689^{ab}	5540^{ab}	3349^{abcd}	3063^{ab}	15641^{ab}
FBL[3]	Perun	3770^{a}	5688^{a}	2977^{cd}	3397^{ab}	15833^{a}
FBL	Perseus	2690^{cd}	5463^{ab}	3227^{bcd}	3033^{ab}	14413^{abcd}
FBL	Hostyn	3277^{abc}	5358^{ab}	3932^{abc}	3494^{ab}	16061^{a}
FBL	Paulita	2977^{bc}	5485^{ab}	3797^{abc}	3300^{ab}	15559^{abc}
FBL	Achilles	2990^{abc}	5215^{ab}	3236^{bcd}	2950^{ab}	14390^{abcd}
LSD (0.05)		789.8	817.0	986.5	828.0	1761

[1]FPF: *Festulolium pabulare* festucoid (Tall fescue x Italian ryegrass x Tall fescue)

[2] FPL: *Festulolium pabulare* loloid (Tall fescue x Italian ryegrass x Italian ryegrass)

[3] FBL: *Festulolium braunii* loloid (Meadow fescue x Italian ryegrass x Italian ryegrass)

LSD (0.05) compares over cultivars within season

[abc]Means with no common superscript differ significantly

Table 6: The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of festulolium, fescue and ryegrass cultivars during year 1

Species	Cultivar	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May
TF[1]	Kora	5.5^{efg}	40.6^{efgh}	79.9^{cdefg}	81.6^{abcde}	42.6^{a}	67.1^{bc}	40.6^{def}	14.8^{efghi}	50.4^{ab}	44.6^{ab}	31.6^{abcd}
TF	Tuscany	4.6^{fg}	27.4^{i}	63.7^{fgh}	65.4^{gh}	44.0^{a}	56.5^{bcd}	59.7^{abcde}	25.2^{abc}	46.1^{abcde}	45.0^{a}	25.6^{bcd}
TF	Baroptima	3.9^{fg}	36.7^{fghi}	60.9^{gh}	70.6^{cdefgh}	46.7^{a}	66.8^{bc}	49.4^{bcdef}	15.7^{efgh}	48.2^{abcd}	44.9^{ab}	25.0^{bcd}
TF	Verdant	25.2^{a}	61.3^{a}	84.8^{bcde}	57.6^{h}	12.9^{g}	65.3^{bc}	66.7^{ab}	8.1^{hi}	54.6^{ab}	38.6^{abc}	35.9^{a}
TF	Jenna	8.4^{def}	44.1^{cdefg}	87.9^{bcd}	67.7^{fgh}	25.3^{def}	54.2^{cd}	63.7^{abc}	21.5^{bcde}	51.7^{ab}	42.0^{abc}	28.3^{abcd}
MF[2]	Laura	6.9^{defg}	50.1^{abcde}	80.6^{cdefg}	68.6^{efgh}	23.2^{efg}	55.0^{cd}	52.6^{abcdef}	15.4^{efghi}	32.5^{de}	37.1^{abc}	23.6^{cd}
MF	Jamaica	4.0^{fg}	47.5^{bcdef}	86.9^{bcd}	$77.3^{abcdefg}$	30.3^{bcde}	62.3^{bcd}	52.6^{abcdef}	12.8^{fghi}	31.3^{e}	43.7^{ab}	29.7^{abcd}
FPF[3]	Felina	1.5^{g}	25.8^{i}	49.8^{h}	69.9^{defgh}	36.3^{abcd}	62.7^{bc}	60.9^{abcd}	17.1^{defg}	45.0^{abcde}	35.7^{abc}	22.9^{d}
FPF	Hykor	8.1^{def}	32.9^{ghi}	70.8^{defgh}	$78.7^{abcdefg}$	27.8^{cde}	66.8^{bc}	53.4^{abcdef}	16.5^{defg}	52.1^{ab}	35.5^{abc}	27.8^{abcd}
FPF	Mahulena	3.7^{fg}	41.6^{defgh}	72.0^{defg}	73.3^{bcdefg}	43.3^{a}	60.5^{bcd}	64.5^{abc}	26.8^{abc}	46.7^{abcde}	40.9^{abc}	34.8^{ab}
FPF	Rebab	3.1^{fg}	31.2^{hi}	59.5^{gh}	68.7^{efgh}	44.7^{a}	64.2^{bc}	52.6^{abcdef}	31.1^{a}	50.5^{ab}	43.3^{ab}	31.9^{abcd}
FPF	HZ	3.8^{fg}	30.7^{hi}	68.4^{defgh}	68.2^{efgh}	40.6^{ab}	57.8^{bcd}	72.7^{a}	21.7^{bcde}	51.6^{ab}	36.1^{abc}	23.4^{d}
FPF	Fojtan	6.3^{defg}	33.6^{ghi}	64.2^{efgh}	73.6^{bcdefg}	38.9^{abc}	51.9^{cd}	62.8^{abcd}	27.9^{ab}	50.4^{ab}	43.1^{ab}	26.2^{abcd}
FPL[4]	Lofa	11.5^{cde}	45.7^{bcdef}	83.1^{bcdef}	81.3^{abcdef}	19.2^{efg}	46.5^{d}	36.2^{f}	7.9^{i}	33.7^{cde}	35.8^{abc}	26.2^{abcd}
FPL	Becva	19.6^{ab}	48.3^{bcdef}	115^{a}	68.1^{efgh}	14.1^{fg}	57.0^{bcd}	50.3^{bcdef}	10.2^{ghi}	41.6^{abcde}	39.8^{abc}	28.0^{abcd}
FBL[5]	Perun	20.7^{ab}	47.2^{bcdef}	98.9^{abc}	79.9^{abcdef}	24.6^{defg}	57.6^{bcd}	32.2^{f}	14.6^{efghi}	48.3^{abcd}	40.3^{abc}	32.4^{abcd}
FBL	Perseus	11.7^{cde}	43.7^{cdefg}	88.1^{bcd}	84.3^{abc}	23.4^{efg}	63.5^{bc}	35.5^{f}	14.1^{efghi}	39.1^{bcde}	36.8^{abc}	32.3^{abcd}
FBL	Hostyn	15.2^{bc}	50.1^{abcde}	88.5^{bcd}	81.2^{abcdef}	22.2^{efg}	72.3^{b}	46.4^{bcdef}	19.2^{cdef}	48.4^{abcd}	41.0^{abc}	35.1^{ab}
FBL	Paulita	12.4^{cd}	49.9^{abcde}	84.6^{bcdef}	86.5^{ab}	25.7^{def}	66.1^{bc}	45.5^{bcdef}	21.6^{bcde}	52.4^{ab}	33.2^{abc}	31.6^{abcd}
FBL	Achilles	11.5^{cde}	53.2^{abcd}	86.3^{bcd}	79.6^{abcdef}	20.9^{efg}	54.0^{cd}	43.5^{cdef}	16.1^{efg}	44.9^{abcde}	36.2^{abc}	23.9^{cd}
PR[6]	Bealy	20.1^{ab}	53.7^{abc}	97.8^{abc}	75.9^{bcdefg}	30.1^{bcde}	88.6^{a}	51.8^{abcdef}	24.0^{abcd}	57.5^{a}	39.8^{abc}	32.3^{abcd}
PR	Bronsyn	11.4^{cde}	56.9^{ab}	87.1^{bcd}	90.8^{a}	29.8^{bcde}	61.2^{bcd}	34.4^{f}	12.5^{fghi}	32.3^{de}	28.5^{c}	26.6^{abcd}
IR[7]	Jeanne	22.8^{a}	45.9^{bcdef}	96.6^{abc}	83.2^{abcd}	24.7^{defg}	52.3^{bcd}	37.8^{ef}	9.3^{ghi}	44.0^{abcde}	31.3^{bc}	34.3^{ab}
IR	Parfait	19.9^{ab}	52.7^{abcd}	104^{ab}	74.0^{bcdefg}	19.1^{efg}	63.1^{bc}	36.1^{f}	21.4^{bcde}	48.9^{abc}	40.9^{abc}	33.8^{abc}
LSD (0.05)		6.28	11.60	21.14	13.74	12.00	16.03	22.31	7.78	16.16	13.60	10.25

[1] TF: Tall fescue, [2] MF: Meadow fescue, [3] FPF: *Festulolium pabulare* festucoid (Tall fescue x Italian ryegrass x Tall fescue),
[4] FPL: *Festulolium pabulare* loloid (Tall fescue x Italian ryegrass x Italian ryegrass), [5] FBL: *Festulolium braunii* loloid (Meadow fescue x Italian ryegrass x Italian ryegrass), [6]PR: Perennial ryegrass, [7]IR: Italian ryegrass
LSD (0.05) compares over cultivars within month
^{abc}Means with no common superscript differ significantly

Table 7: Total seasonal and annual dry matter production (kg DM ha^{-1}) of festulolium, fescue and ryegrass cultivars during year 1

Species	Cultivar	Winter	Spring	Summer	Autumn	Annual
TF[1]	Kora	1926^{ijk}	5672^{ab}	3494^{bcdef}	3553^{abc}	14646^{defghi}
TF	Tuscany	1397^{kl}	4800^{cd}	4019^{abcd}	3269^{abcde}	13485^{hij}
TF	Baroptima	1632^{jkl}	4936^{bcd}	3763^{bcdef}	3309^{abcd}	13639^{hij}
TF	Verdant	4721^{a}	4364^{d}	3990^{abcd}	3629^{ab}	16705^{ab}
TF	Jenna	2349^{fghij}	5054^{abcd}	3956^{abcde}	3424^{abc}	14783^{cdefgh}
MF[2]	Laura	2391^{fghi}	4818^{cd}	3498^{bcdef}	2605^{ef}	13313^{hij}
MF	Jamaica	1995^{ghijk}	5425^{abc}	3634^{bcdef}	2917^{cdef}	13970^{ghi}
FPF[3]	Felina	960^{l}	4312^{d}	4002^{abcd}	2911^{cdef}	12184^{j}
FPF	Hykor	1957^{hijk}	4927^{bcd}	3893^{abcde}	3248^{abcde}	14025^{fghi}
FPF	Mahulena	1505^{kl}	5235^{abc}	4309^{ab}	3434^{abc}	14483^{defghi}
FPF	Rebab	1247^{kl}	4787^{cd}	4205^{abc}	3526^{abc}	13764^{hij}
FPF	HZ	1425^{kl}	4923^{bcd}	4317^{ab}	3124^{abcdef}	13788^{hij}
FPF	Fojtan	1554^{kl}	4900^{bcd}	4044^{abcd}	3359^{abc}	13856^{hi}
FPL[4]	Lofa	2744^{efg}	5123^{abcd}	2583^{g}	2679^{def}	13129^{ij}
FPL	Becva	3689^{bcd}	5540^{abc}	3349^{cdefg}	3063^{abcdef}	15641^{bcdef}
FBL[5]	Perun	3770^{bc}	5688^{ab}	2977^{fg}	3397^{abc}	15833^{bcde}
FBL	Perseus	2690^{efgh}	5463^{abc}	3227^{defg}	3033^{abcdef}	14413^{efghi}
FBL	Hostyn	3277^{bcde}	5358^{abc}	3932^{abcde}	3494^{abc}	16061^{bcd}
FBL	Paulita	2977^{def}	5485^{abc}	3797^{abcdef}	3300^{abcd}	15559^{bcdefg}
FBL	Achilles	2990^{def}	5215^{abc}	3236^{defg}	2950^{bcdef}	14390^{efghi}
PR[6]	Bealy	3927^{b}	5695^{ab}	4692^{a}	3648^{a}	17961^{a}
PR	Bronsyn	3096^{cdef}	5780^{a}	3090^{efg}	2449^{f}	14414^{efghi}
IR[7]	Jeanne	3952^{b}	5715^{ab}	2981^{fg}	3082^{abcdef}	15729^{bcde}
IR	Parfait	3864^{b}	5521^{abc}	3439^{bcdefg}	3467^{abc}	16291^{bc}
LSD (0.05)		750.4	819.9	898.7	679.2	1626

[1] TF: Tall fescue, [2] MF: Meadow fescue, [3] FPF: *Festulolium pabulare* festucoid (Tall fescue x Italian ryegrass x Tall fescue),
[4] FPL: *Festulolium pabulare* loloid (Tall fescue x Italian ryegrass x Italian ryegrass), [5] FBL: *Festulolium braunii* loloid (Meadow fescue x Italian ryegrass x Italian ryegrass), [6]PR: Perennial ryegrass, [7]IR: Italian ryegrass

LSD (0.05) compares over cultivars within season

^{abc}Means with no common superscript differ significantly

Paulita, but higher (P<0.05) than the remaining Festulolium cultivars. During winter the FPL cultivar Becva and FBL cultivar Perun were the only Festulolium cultivars that had a similar (P>0.05) seasonal dry matter production to Parfait, with that of the remaining festulolium cultivars lower (P<0.05). During summer all the Festulolium cultivars had a similar (P>0.05) dry matter production to Parfait. During spring and summer the only Festulolium cultivars that had a lower (P<0.05) dry matter production than Parfait were Felina (FPF) and Lofa (FPL), respectively.

b) Festulolium cultivars compared to fescue

The fescue cultivar Verdant had the highest (P<0.05) total annual DM production of the fescue cultivars and will be used as the fescue parent to compare the production potential of Festulolium cultivars. During winter the DM production of Verdant was higher (P<0.05) than all the Festulolium cultivars. Verdant had a (P<0.05) lower dry matter production than all the FBL cultivars, as well as the FPL cultivar Becva and the FPF cultivar Mahulena during spring, but similar (P>0.05) to the rest of the Festulolium cultivars. The DM production of Verdant was higher (P<0.05) than Lofa and Perun during summer, but similar (P>0.05) to the rest of the festulolium cultivars. The autumn production of the Festulolium cultivars were similar (P>0.05) to that of Verdant, except for Lofa and Felina for which it was lower(P<0.05). The total annual dry matter production of Verdant was similar (P>0.05) to Becva (FPL), Perun (FBL), Hostyn (FBL) and Paulita (FBL), but higher (P<0.05) than the rest.

Of the Festulolium cultivars Hostyn had the highest annual DM production, with similar (P>0.05) dry matter production achieved by Mahulena, Becva, Perun, Hostyn and Paulita. Hostyn also had a similar production to the tall fescue cultivars Verdant, Kora and Jenna, as well as the two Italian ryegrass cultivars.

Conclusions

1. Both *Festulolium pabulare* varieties had a similar annual dry matter production potential to their fescue parent (tall fescue), but lower than Italian ryegrass.
2. When comparing the two *Festulolium pabulare* varieties, the loloid variety showed a superior winter and spring production, while the festucoid variety had a higher summer production.
3. The *Festulolium brauni* variety was the only Festulolium variety that had a similar total annual dry matter production to Italian ryegrass and a higher total annual dry matter production than its fescue parent (Meadow Fescue).
4. When compared with each other the *Festulolium braunii* variety had a higher total annual dry matter production than the *Festulolium pabulare* festucoid variety, but similar to the *Festulolium pabulare* loloid variety. It would thus appear that loloid types have the ability to establish more rapidly than festucoid types and, as result, are higher yielding in the first year.
5. Based on the first year of data, the recommended Festulolium cultivars are all loloid types namely: Becva (FPL), Perun (FBL), Hostyn (FBL) and Paulita (FBL) All these cultivars had a similar annual dry matter production the Tall Fescue cultivar

Verdant and Italian ryegrass cultivar Parfait. Of the festucoid varieties Mahulena had the highest production during year one

6. Bealy, a perennial ryegrass, was the highest yielding cultivar during year one, with none of the Festulolium cultivars out-yielding it in the first year of production.
7. Further evaluation of Festulolium cultivars in successive years is required to determine whether these cultivars will show superior persistence to annual and perennial ryegrass in this region.
8. Festuloliums will have to be evaluated under grazing conditions to determine whether they show a higher palatability and intake compared to fescue when grazed by animals.

Message to the Farmer

New perennial grasses are available and can be included in fodder-flow programs.

Care must be taken when selecting cultivars and species to utilise in a system, with selection based on seasonal production potential.

Further evaluation of Festuloliums is required in this region to determine persistence, grazing tolerance and palatability.

References

ARC. 2005. Instructions for the completion of National Ryegrass Evaluation Programme.

Akgun I, Tosun M, Sengul S. 2008. Comparison of agronomic characters of Festulolium, Festuca pratensis huds. And Lolium multiflorum lam. Genorypes under high elevation conditions in turkey. Bangladesh Journal of Botany. 37:1-6.

Beyers CP. 1973. Bemesting van aangeplante wiedings. *Winterreën Spesiale Uitgawe* 5, 54-59.

Botha PR. 2002. Die gebruik van vogspanningmeters vir besproeiingskedulering by weidings. *Weidingskursus Inligtingsbundel 2002*. Suid Kaap Landbou-ontwikkelinsentrum, Departement Landbou Wes-Kaap. pp 141-149.

Ghesquire, M, Humphreys M, & Zwierzykowski Z. 2010. *eprints*. Retrieved August 1, 2011, from http://eprints.hdl/handle/2160/7028

Kopecky D, Lukaszewski AJ, Dolezel J. 2008. Cytogenics of Festulolium (*Festuca* x *Lolium* hybrids). *Cytogenetics and Genome Research*. 120:370-383.

Ott RL. (1998) An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051)

Reed KFM. 1996. Improving the adaptation of perennial ryegrass, tall fescue, phalaris and cocksfoot for Australia. *New Zealand Journal of Agricultural Research*. 39:457-464.

Soil Classification Workgroup. 1991. Soil Classification, a Taxonomic system for South Africa. Memoirs on the Natural Agricultural Resources of South Africa. Nr 15. Department of Agricultural Development, Pretoria

THE EVALUATION OF ANNUAL RYEGRASS CULTIVARS IN THE SOUTHERN CAPE: 2010 TO 2011

J van der Colf[1] & PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

Dairy and beef production in the southern Cape is based primarily on planted pastures. Annual ryegrass varieties, such as Italian ryegrass (*Lolium multiflorum* var. *italicum*) and westerwolds ryegrass (*L. multiflorum* var. *westerwoldicum*) are established in both pure swards and strategically over-sown into kikuyu to provide high quality fodder for animals (Botha et al. 2008, Botha and Gerber 2008, Van der Colf 2010), forming an important part of fodder-flow systems in the southern Cape. New cultivars are continuously being made available and the evaluation of these cultivars in terms of seasonal and annual dry matter production potential is required to assist farmers in selecting the species/cultivar best suited to a specific pasture systems. The aim of this study was to evaluate the production potential of annual ryegrass cultivars in the southern Cape.

Materials and methods

This study was carried out in association with the Agricultural Research Council (ARC), with two separate trials established during May 2010 and April 2011, respectively. Similar methods were utilised during both years/studies. The species, ploidy and cultivar name of the annual ryegrass cultivars evaluated during 2010 and 2011 is given in Table 1 and Table 2, respectively.

These studies were carried out on the Outeniqua Research Farm near George (Altitude 201m, 33° 58’ 38” S and 22° 25’ 16” E, rainfall 728 mm per year) in the Western Cape of South Africa under sprinkler irrigation and on a Witfontein soil form. Irrigation scheduling was done according to tensiometer readings, commencing at –25 kPa and terminated at –10 kPa (Botha 2002). Prior to establishment soil samples were taken to a depth of 150mm and analysed for Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S, and C levels. Fertiliser was applied according to the soil analysis to raise soil P level to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and pH (KCl) to 5.5 (Beyers 1973). Treatments received 50 kg N ha^{-1} and 50 kg K ha^{-1} after each harvest.

The trial area was tilled with a konskilde prior to establishment to create a seedbed and to mechanically eradicate weeds. Treatments were established in rows on 2.1m x 6m plots at a seeding rate of 25 kg ha^{-1} for diploids and 30 kg ha^{-1} for tetraploids. Both trials consisted of a randomized block design with three replicates per treatment. Plots were harvested on a 28 day cycle. A strip of pasture (1.27m x 4.8m = 6.1m^2) was cut to a height of 50 mm above ground level and weighed.

Approximately 500g of the sample was placed in a brown paper bag, weighed, dried at 60°C for 72 hours and weighed again to determine dry matter content.

Table 1: Species, ploidy and cultivar name of annual ryegrass cultivars evaluated during 2010

Species	**Ploidy**	**Cultivar**
Westerwolds ryegrass	Diploid	Mispah
Westerwolds ryegrass	Diploid	Performer
Westerwolds ryegrass	Diploid	Bruiser
Westerwolds ryegrass	Tetraploid	Archie
Westerwolds ryegrass	Tetraploid	Captain
Westerwolds ryegrass	Tetraploid	Primora
Westerwolds ryegrass	NA	K2W2
Westerwolds ryegrass	NA	K2W1
Italian ryegrass	Diploid	Agriton
Italian ryegrass	Diploid	Tabu
Italian ryegrass	Diploid	Dargle
Italian ryegrass	Diploid	Supreme Q
Italian ryegrass	Diploid	Agriboost
Italian ryegrass	Diploid	Sustainer
Italian ryegrass	Diploid	Warrior
Italian ryegrass	Diploid	Enhancer
Italian ryegrass	Tetraploid	Feast II
Italian ryegrass	NA	K2I1
Italian ryegrass	NA	K2I2
Mixture	NA	Voyager
Mixture	NA	Voyager 12
Mixiture	NA	Voyager 31

Table 2: Species, ploidy and cultivar name of annual ryegrass cultivars evaluated during 2011

Species	**Ploidy**	**Cultivar**
Westerwolds ryegrass	Diploid	Mispah
Westerwolds ryegrass	Diploid	Performer
Westerwolds ryegrass	Diploid	Bruiser
Westerwolds ryegrass	Tetraploid	Archie
Westerwolds ryegrass	Tetraploid	Captain
Westerwolds ryegrass	Tetraploid	Primora
Italian ryegrass	Diploid	Agriton
Italian ryegrass	Diploid	Tabu
Italian ryegrass	Diploid	Dargle
Italian ryegrass	Diploid	Supreme Q
Italian ryegrass	Diploid	Agriboost
Italian ryegrass	Diploid	Sustainer
Italian ryegrass	Diploid	Warrior
Italian ryegrass	Tet	Feast II
Mixture	Mix	Voyager
Mixture	Mix	Voyager 12
Mixture	Mix	Voyager 31

An appropriate analysis of variance was performed on monthly growth rate, total seasonal dry matter production and annual dry matter production. The assumption of normality of the residuals (Shapiro & Wilk 1965) was fulfilled. Therefore, the results are statistically sound. A Student least significant difference (LSD) at 5 % significance level was done to compare the treatment means (Ott1998). The STATS module of SAS version 9.2 (SAS institute Inc. 2008) was used to analyze the data.

Results and discussion

Year 2010

The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of annual ryegrass cultivars evaluated during 2010 is shown in Table 3. The Italian ryegrass cultivar Tabu was the only cultivar that had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate from July to December.

Table 3: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of annual ryegrass cultivars during 2010

Species	Ploidy	Cultivar	July	August	Sept	Oct	Nov	Dec
Westerwolds	Dip	Mispah	10.3^{b}	49.8^{abcd}	40.3^{ab}	25.2^{defg}	20.7^{def}	$24.4^{cdefghi}$
Westerwolds	Dip	Performer	13.8^{a}	52.7^{ab}	34.3^{bcde}	30.7^{bcde}	31.1^{a}	26.0^{cdefgh}
Westerwolds	Dip	Bruiser	12.0^{ab}	48.9^{abcde}	35.4^{abcd}	17.2^{fg}	14.6^{gh}	11.8^{j}
Westerwolds	Tet	Archie	12.2^{ab}	43.2^{defg}	31.4^{cde}	25.3^{defg}	18.8^{efg}	18.6^{ghij}
Westerwolds	Tet	Captain	13.3^{a}	54.8^{a}	36.9^{abc}	16.4^{fg}	22.4^{cde}	$23.7^{cdefghi}$
Westerwolds	Tet	Primora	12.6^{ab}	44.9^{cdefg}	34.3^{bcde}	29.3^{cde}	22.0^{cdef}	15.9^{hij}
Westerwolds	NA	K2W2	11.1^{ab}	46.3^{bcdef}	40.6^{ab}	38.4^{abc}	26.5^{abc}	$28.8^{abcdefg}$
Westerwolds	NA	K2W1	11.3^{ab}	41.4^{fg}	36.0^{abcd}	31.9^{bcde}	20.6^{def}	19.1^{fghij}
Italian	Dip	Agriton	12.8^{ab}	46.0^{bcdef}	39.7^{ab}	29.3^{cde}	22.2^{cde}	30.5^{abcde}
Italian	Dip	Tabu	13.2^{ab}	48.7^{abcde}	41.1^{ab}	42.7^{ab}	28.1^{ab}	38.8^{a}
Italian	Dip	Dargle	11.2^{ab}	48.2^{abcdef}	38.2^{abc}	27.0^{cdef}	20.8^{def}	$23.7^{cdefghi}$
Italian	Dip	Supreme Q	12.7^{ab}	49.0^{abcde}	35.5^{abcd}	44.6^{a}	25.2^{bcd}	30.7^{abcde}
Italian	Dip	Agriboost	12.4^{ab}	47.0^{bcdef}	42.4^{a}	31.7^{bcde}	24.7^{bcd}	31.6^{abcd}
Italian	Dip	Sustainer	11.4^{ab}	43.1^{defg}	37.8^{abc}	30.8^{bcde}	17.2^{fg}	20.8^{efgij}
Italian	Dip	Warrior	12.3^{ab}	45.4^{cdef}	35.3^{abcd}	35.7^{abcd}	28.9^{ab}	37.8^{ab}
Italian	Dip	Enhancer	13.6^{a}	50.2^{abc}	37.3^{abc}	37.5^{abc}	25.5^{bcd}	34.0^{abc}
Italian	Tet	Feast II	11.7^{ab}	45.7^{bcdef}	33.5^{bcde}	35.8^{abcd}	26.3^{abc}	29.8^{abcdef}
Italian	NA	K2I1	12.0^{ab}	42.5^{efg}	41.1^{ab}	44.5^{a}	25.1^{bcd}	28.0^{bcdefg}
Italian	NA	K2I2	11.4^{ab}	38.4^{g}	33.8^{bcd}	37.1^{abcd}	24.4^{bcd}	14.9^{ij}
Mix	NA	Voyager	13.5^{a}	47.2^{bcdef}	28.3^{def}	29.4^{cde}	27.4^{ab}	31.2^{abcde}
Mix	NA	Voyager 12	13.6^{a}	52.6^{ab}	26.7^{ef}	13.5^{g}	12.1^{h}	23.2^{defghi}
Mix	NA	Voyager 31	12.0^{ab}	48.1^{abcdef}	23.3^{f}	22.0^{efg}	18.9^{efg}	$21.8^{defghij}$
LSD (0.05)			2.891	7.003	7.813	12.08	4.884	10.74

LSD (0.05) compares within month.

^{abc}Means with no common superscript differ significantly

The total seasonal and annual DM production (kg DM ha^{-1}) of annual ryegrass cultivars evaluated during 2010 is shown in Table 4. The Italian ryegrass cultivars Tabu, Suprreme Q, Agriboost and Enhancer had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production during all seasons. The highest ($P<0.05$) annual DM production was achieved by the Italian ryegrass cultivar Tabu, with similar($P>0.05$) production obtained from the Italian ryegrass cultivars Supreme Q, Agriboost, Warrior and Enhancer, as well as the Westerwolds ryegrass cultivars Performer and K2W2.

Table 4: Total seasonal and annual dry matter production (kg DM ha^{-1}) of annual ryegrass cultivars during 2010

Species	Ploidy	Cultivar	Winter	Spring	Summer	Annual
Westerwolds	Dip	Mispah	2666^{bcdef}	2430^{cde}	1049^{cdefghi}	6145^{cdefg}
Westerwolds	Dip	Performer	3006^{ab}	2721^{abcd}	1120^{cdefgh}	6848^{abc}
Westerwolds	Dip	Bruiser	2736^{abcdef}	1887^{fg}	509^{j}	5132^{g}
Westerwolds	Tet	Archie	2523^{defg}	2252^{def}	799^{ghij}	5575^{efg}
Westerwolds	Tet	Captain	3056^{a}	2102^{ef}	1019^{cdefghi}	6177^{cdef}
Westerwolds	Tet	Primora	2619^{bcdefg}	2419^{cde}	681^{hij}	5719^{efg}
Westerwolds	NA	K2W2	2569^{defg}	2989^{ab}	1238^{abcdefg}	6795^{abcd}
Westerwolds	NA	K2W1	2392^{fg}	2513^{bcde}	822^{fghij}	5727^{efg}
Italian	Dip	Agriton	2671^{abcdef}	2574^{bcde}	1312^{abcde}	6557^{bcde}
Italian	Dip	Tabu	2805^{abcde}	3177^{a}	1670^{a}	7652^{a}
Italian	Dip	Dargle	2654^{bcdefg}	2427^{cde}	1019^{cdefghi}	6100^{cdefg}
Italian	Dip	Supreme Q	2788^{abcde}	3006^{ab}	1320^{abcde}	7113^{abc}
Italian	Dip	Agriboost	2686^{abcdef}	2789^{abc}	1357^{abcd}	6833^{abc}
Italian	Dip	Sustainer	2462^{efg}	2441^{cde}	893^{efghij}	5797^{defg}
Italian	Dip	Warrior	2617^{cdefg}	2815^{abc}	1625^{ab}	7057^{abc}
Italian	Dip	Enhancer	2896^{abcd}	2843^{abc}	1460^{abc}	7199^{ab}
Italian	Tet	Feast II	2587^{defg}	2703^{abcd}	1283^{abcdef}	6572^{bcde}
Italian	NA	K2I1	2480^{efg}	3156^{a}	1205^{bcdefg}	6842^{abc}
Italian	NA	K2I2	2276^{g}	2705^{abcd}	640^{ij}	5621^{efg}
Mix	NA	Voyager	2768^{abcdef}	2387^{cde}	1343^{abcde}	6498^{bcde}
Mix	NA	Voyager 12	2992^{abc}	1465^{g}	997^{defghi}	5454^{fg}
Mix	NA	Voyager 31	2704^{abcdef}	1808^{fg}	938^{defghij}	5450^{fg}
LSD (0.05)			388.4	494.9	461.6	1014

LSD (0.05) compares within season and year

^{abc}Means with no common superscript differ significantly

Year 2011

The mean monthly growth rate of annual ryegrass cultivars evaluated during 2011 is shown in Table 5. The Italian ryegrass cultivar Warrior was the only cultivar that had the highest (P<0.05) or similar (P>0.05) to the highest growth rate from June to December. From June to August (winter) the Westerwold ryegrass cultivars Mispah and Performer and Italian ryegrass cultivars Dargle, Supreme Q and Warrior had the highest (P<0.05) or similar (P>0.05) to the highest growth rates during all months. From September to November (Spring) the Italian ryegrass cultivars Tabu and Warrior were the only cultivars that had the highest (P<0.05) or similar (P>0.05) to the highest growth rate during all months.

The total seasonal and annual Species, ploidy and cultivar name of annual ryegrass cultivars evaluated during DM production of annual ryegrass cultivars during 2011 is shown in Table 6. The highest (P<0.05) annual DM production was for the Italian ryegrass cultivar Warrior, with similar (P>0.05) production obtained by Italian ryegrass cultivars Tabu and Agriboost and the Westerwolds ryegrass cultivar Performer. The Westerwolds ryegrass cultivar Performer and Italian ryegrass cultivar Warrior were the only cultivars that had the highest (P<0.05) or similar (P>0.05) to the highest seasonal dry matter production throughout all seasons.

Table 5: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of annual ryegrass cultivars during 2011.

Species	**Ploidy**	**Cultivar**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**
Westerwolds	Dip	Mispah	24.4^{abcd}	45.0^{a}	49.2^{abc}	45.5^{bcd}	26.3^{efgh}	47.9^{abcde}	22.9^{abc}
Westerwolds	Dip	Performer	26.2^{abc}	51.7^{a}	51.8^{a}	51.8^{b}	40.7^{ab}	55.7^{ab}	23.0^{abc}
Westerwolds	Dip	Bruiser	27.1^{a}	42.5^{a}	37.8^{f}	22.4^{f}	18.4^{hi}	-	-
Westerwolds	Tet	Archie	22.9^{abcd}	39.1^{a}	42.3^{cdef}	36.8^{de}	22.2^{ghi}	31.4^{fgh}	10.3^{ef}
Westerwolds	Tet	Captain	26.4^{ab}	40.1^{a}	38.4^{ef}	23.9^{f}	15.1^{i}	25.0^{h}	8.63^{f}
Westerwolds	Tet	Primora	21.9^{bcd}	41.7^{a}	39.7^{def}	45.5^{bcd}	31.3^{cdef}	38.8^{defg}	13.6^{def}
Italian	Dip	Agriton	20.9^{d}	42.5^{a}	42.0^{def}	38.2^{de}	25.2^{fgh}	41.1^{cdef}	15.1^{cdef}
Italian	Dip	Tabu	21.8^{bcd}	43.3^{a}	42.4^{cdef}	68.5^{a}	39.1^{abc}	52.3^{abcd}	21.3^{abcd}
Italian	Dip	Dargle	26.6^{ab}	43.0^{a}	45.5^{abcd}	41.5^{cde}	23.1^{fghi}	42.9^{bcdef}	19.7^{bcd}
Italian	Dip	Supreme Q	22.7^{abcd}	42.1^{a}	43.4^{bcdef}	48.2^{bc}	29.5^{defg}	39.4^{cdefg}	13.8^{def}
Italian	Dip	Agriboost	20.8^{d}	49.5^{a}	45.6^{abcd}	52.5^{b}	34.3^{bcde}	52.8^{abc}	23.9^{abc}
Italian	Dip	Sustainer	27.1^{a}	44.9^{a}	39.9^{def}	33.3^{e}	21.1^{ghi}	35.1^{efgh}	17.9^{bcd}
Italian	Dip	Warrior	23.3^{abcd}	51.9^{a}	50.4^{ab}	63.4^{a}	42.8^{ab}	57.0^{a}	29.7^{a}
Italian	Tet	Feast II	21.4^{cd}	40.0^{a}	45.2^{abcde}	51.8^{b}	43.8^{a}	40.4^{cdefg}	16.2^{bcdef}
Mix	Mix	Voyager	23.5^{abcd}	44.7^{a}	40.7^{de}	41.8^{cde}	39.4^{abc}	42.4^{bcdef}	24.9^{ab}
Mix	Mix	Voyager 12	20.9^{d}	39.9^{a}	41.1^{def}	22.9^{f}	20.5^{hi}	26.9^{gh}	7.98^{f}
Mix	Mix	Voyager 31	22.7^{abcd}	42.8^{a}	40.3^{def}	34.9^{e}	36.2^{abcd}	42.7^{bcdef}	15.0^{cdef}
LSD (0.05)			4.91	15.54	7.105	8.749	8.736	13.66	9.134

LSD (0.05) compares within month.

^{abc}Means with no common superscript differ significantly

Table 6: Total seasonal and annual dry matter production (kg DM ha^{-1}) of annual ryegrass cultivars during 2011

Species	Ploidy	Cultivar	Winter	Spring	Summer	Annual
Westerwolds	Dip	Mispah	5619^{abc}	3487^{def}	665^{abc}	9771^{bcde}
Westerwolds	Dip	Performer	6191^{a}	4303^{abc}	667^{abc}	11160^{ab}
Westerwolds	Dip	Bruiser	5312^{cde}	1207^{k}	-	6519^{i}
Westerwolds	Tet	Archie	4975de	2642^{ghi}	298^{ef}	7916^{fghi}
Westerwolds	Tet	Captain	5140^{cde}	1863^{jk}	250^{f}	7254^{ghi}
Westerwolds	Tet	Primora	4997^{cde}	3373^{defg}	394^{def}	8765^{ef}
Italian	Dip	Agriton	5031^{cde}	3039^{fgh}	437^{cdef}	8507^{efgh}
Italian	Dip	Tabu	5145^{cde}	4681^{ab}	617^{abcd}	10442^{abc}
Italian	Dip	Dargle	5532^{bcd}	3137^{fgh}	572^{bcd}	9240^{cdef}
Italian	Dip	Supreme Q	5157^{cde}	3422^{def}	399^{def}	8979^{def}
Italian	Dip	Agriboost	5538^{bcd}	4067^{abcd}	692^{abc}	10297^{abcd}
Italian	Dip	Sustainer	5516^{bcd}	2607^{hi}	519^{bcde}	8642^{efg}
Italian	Dip	Warrior	5970^{ab}	4759^{a}	861^{a}	11590^{a}
Italian	Tet	Feast II	5014^{cde}	3963^{bcde}	469^{bcdef}	9446^{cde}
Mix	Mix	Voyager	5298^{cde}	3586^{cdef}	723^{ab}	9607^{cde}
Mix	Mix	Voyager 12	4857^{e}	2037^{ij}	231^{f}	7126^{hi}
Mix	Mix	Voyager 31	5122^{cde}	3289^{efgh}	434^{cdef}	8844^{ef}
LSD (0.05)			631.0	733.1	264.8	1411

LSD (0.05) compares within month.
^{abc}Means with no common superscript differ significantly

Conclusions

- The growth rate and seasonal production differed between cultivars.
- The Italian ryegrass cultivars Tabu, Agriboost and Warrior, as well as the westerwolds ryegrass cultivar Performer were among the most productive cultivars during both 2010 and 2011.
- The seasonal spread of growth and dry matter production should be considered when deciding on which ryegrass cultivar to utilise in a pasture system.

Message to the farmer

The choice on which annual ryegrass cultivar or variety to use should be based on the specific purpose of the pasture to be established (for example short term winter feed, planting with companion species, high spring production, silage production or extended growth season) and the seasonal spread of production.

References

Beyers CP. 1973. Bemesting van aangeplante wiedings. *Winterreën Spesiale Uitgawe* 5, 54-59.

Botha PR 2002. Die gebruik van vogspanningmeters vir besproeiing-skedulering by weidings. Weidings-kursus 2002. Inligtingsdag-bundel Suid-Kaap Landbou-ontwikkeling-sentrum.
Departement Landbou Wes-Kaap. pp 141-149.

Botha PR and Gerber HS. 2008. The annual production and botanical composition of perennial ryegrass, Tall fescue, Cocksfoot and clovers over-sown with annual or perennial ryegrass. Outeniqua Research Farm Information day booklet 2008. pp 22, 24.

Botha PR, Gerber HS, Zulu LB. 2008. Die seisoenale droëmateriaalproduksie van Kropaargras, Swenkgras en verskillende meer- en eenjarige raaigrasspesies. Outeniqua Navorsingsplaas Inligtingsdag bun-del 2008. pp 12.

Donaldson CH. 2001. A practical guide to planted pastures. Chapter 4, pp 35.

Ott, R.L. (1998) An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051).

SAS Institute, Inc. (2008), SAS Version 9.2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Shapiro SS and Wilk MB. 1965. An Analysis of Variance Test for Normality (complete samples). Biometrika, 52, 591-611.

Van der Colf J 2010. The production potential of kikuyu (Pennisetum clandestinum) over-sown with ryegrass (Lolium spp.). MSc Thesis. University of Pretoria, South Africa.

THE PRODUCTION POTENTIAL OF PERENNIAL RYEGRASS AND RYEGRASS HYBRIDS IN THE SOUTHERN CAPE

J van der Colf[1], PR Botha[1] & MM Lombard[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

Grass-legume pastures form the backbone of milk and beef production in the southern Cape of South Africa (Botha 2008). Perennial ryegrass (*Lolium perenne*) is a perennial cool-season pasture crop that produces grass of a high quality during spring and autumn (Donaldson 2001). Perennial ryegrass is an important component of these grass-legume mixtures due to the perennial ryegrass's persistence under optimum management (Botha & Gerber 2008).

Previous system trials on Outeniqua Research Farm have indicated that pasture and milk production is higher when kikuyu is over-sown with perennial ryegrass rather than annual ryegrass (Van der Colf et al. 2010). The production system will determine the type of ryegrass used (Ammann et al. 2006) and annual as well as seasonal production of perennial ryegrass pasture will be determined by cultivar (Botha et al. 2008).

Milk and beef producers are constantly searching for productive and adapted cultivars to use in their production systems. These cultivars should be able to produce a sufficient amount of dry matter (DM) sustainably in the Southern Cape of South Africa. In South Africa, a large number of perennial ryegrass (*Lolium perenne*) and ryegrass hybrids (*L. multiflorum* x *L. perenne*; *L. multiflorum* x *Festuca* spp.) are available. In order to determine the best adapted and highest producing cultivar to utilise in pasture systems, it is important that these cultivars be evaluated on a regular basis. The aim of this study was to evaluate the production potential and persistence of 18 perennial ryegrass and ryegrass hybrid cultivars over three years.

Materials and methods

This study was carried out on the Outeniqua Research Farm near George (Altitude 201m, 33° 58' 38" S and 22° 25' 16" E, rainfall 728 mm per year) in the Western Cape of South Africa and was executed under sprinkler irrigation on a Witfontein soil form. Irrigation scheduling was done according to tensiometer readings, commencing at –25 kPa and terminated at –10 kPa (Botha 2002). Fertilizer was applied to raise the soil nutrient levels to soil analysis recommendations. Phosphorous (P) and potassium (K) were applied before planting to raise soil nutrient levels in accordance with the soil analysis report. Nitrogen (N) and K were applied after each cutting at a rate of 50 kg N ha^{-1} and 50 kg K ha^{-1}, respectively.

The trial was planted on the 7th of June 2010. The trial area was tilled with a konskilde to create a seedbed and to mechanically eradicate weeds. Seed was planted in rows and plots rolled with a land roller. Consisting of 18 cultivars (treatments), each treatment was replicated three times. The species, cultivar name, ploidy and seeding rate of perennial ryegrass and perennial ryegrass hybrids evaluated during study is shown in Table 1. The trial layout is described as a randomized block design, consisting of 54 plots. Plot size was 2.1m x 6m (thus 12.6m^2). Plots were sampled on a 28 day cycle. A strip of pasture (1.27m x 4.8m = 6.1m^2) was cut on a height of 50 mm above ground level for pasture sampling. The weight of the cut strip was determined, after which approximately 500g of the sample was placed in a brown paper bag and weighed wet and dry to determine dry matter (DM) content. Samples were dried in an oven at 60°C for 72 hours to determine dry weight.

An appropriate analysis of variance was performed on growth rate, seasonal DM production and total annual DM production. The assumption of normality of the residuals (Shapiro & Wilk 1965) was fulfilled. Therefore, the results are statistically sound. A Student least significant difference (LSD) at 5 % significance level was done to compare the treatment means (Ott1998). The STATS module of SAS version 9.2 (SAS institute Inc. 2008) was used to analyze the data.

Table 1: The species, cultivar, ploidy and seeding rate of perennial ryegrass and ryegrass hybrids evaluated during the study

Species	Cultivar	Ploidy	Seeding rate
Perennial ryegrass	Alto	Diploid	20
Perennial ryegrass	Bronsyn	Diploid	20
Perennial ryegrass	Commando	Diploid	20
Perennial ryegrass	Nui	Diploid	20
Perennial ryegrass	Indiana	Diploid	20
Perennial ryegrass	Bealy	Tetraploid	25
Perennial ryegrass	Sterling	Tetraploid	25
Perennial ryegrass	Impresarrio	Tetraploid	25
Perennial ryegrass	Cheliac	Tetraploid	25
Perennial ryegrass	Polim	Tetraploid	25
Perennial ryegrass	Fitzroy	Tetraploid	25
Perennial ryegrass	Quartet	Tetraploid	25
Perennial x Italian hybrid ryegrass	Fortimo	Tetraploid	25
Perennial x Italian hybrid ryegrass	Storm	Tetraploid	25
Perennial x Italian hybrid ryegrass	Tirna	Tetraploid	25
Perennial x Italian hybrid ryegrass	Solid	Tetraploid	25
Festulolium	Perseus	Tetraploid	25
Tall Fescue	Kora	Hexaploid	25

Results and discussion

The mean monthly growth rate of perennial ryegrass, hybrid ryegrass, Festulolium and fescue cultivars during year 1 and year 2 is shown in Table 2 and Table 3 respectively. The highest growth rate was achieved by different cultivars during different months.

Table 2: Mean monthly growth rate (kg DM ha^{-1}) of perennial ryegrass, hybrid ryegrass, festulolium and fescue cultivars cultivars during year 1

Species	Cultivar	Ploidy	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
PR[1]	Alto	Dip	14.8^{abcd}	59.6^{bcd}	76.9^{abc}	59.3^{abcd}	49.1^{ab}	17.3^{bc}	4.66^{bcd}	16.7^{bcd}	31.5^{bc}	39.4^{abcd}
PR	Bronsyn	Dip	15.6^{ab}	66.3^{ab}	80.8^{abc}	59.5^{abcd}	45.0^{abc}	12.1^{c}	2.09^{efg}	14.2^{bcd}	53.03^{a}	41.2^{abc}
PR	Commando	Dip	10.8^{gh}	44.2^{cd}	75.1^{abc}	55.7^{abcd}	39.6^{abc}	11.6^{c}	4.34^{cde}	17.0^{bcd}	30.32^{bc}	44.0^{a}
PR	Nui	Dip	16.4^{a}	56.0^{bcd}	67.8^{c}	50.3^{d}	37.9^{bc}	16.7^{bc}	1.59^{g}	0.68^{e}	27.9^{bc}	39.6^{abcd}
PR	Indiana	Dip	14.8^{abcd}	52.5^{bcd}	75.9^{abc}	62.4^{ab}	42.0^{abc}	16.5^{bc}	1.82^{fg}	16.7^{bcd}	31.6^{bc}	37.3^{abcd}
PR	Bealy	Tet	17.0^{a}	59.3^{bcd}	83.5^{ab}	58.1^{abcd}	47.1^{abc}	19.1^{bc}	6.07^{bc}	22.3^{b}	30.2^{bc}	37.9^{abcd}
PR	Sterling	Tet	11.9^{efg}	54.6^{bcd}	69.3^{bc}	58.4^{abcd}	37.4^{bc}	12.3^{c}	1.91^{fg}	19.1^{bc}	43.3^{abc}	37.5^{abcd}
PR	Impresarrio	Tet	14.2^{abcdef}	55.2^{bcd}	80.7^{abc}	59.9^{abc}	34.7^{c}	17.3^{bc}	2.01^{fg}	6.92^{cde}	33.9^{abc}	33.2^{bcde}
PR	Cheliac	Tet	12.1^{defg}	58.5^{bcd}	72.4^{abc}	59.7^{abcd}	52.4^{a}	14.9^{bc}	1.89^{fg}	7.94^{cde}	34.3^{abc}	31.5^{cde}
PR	Polim	Tet	12.4^{cdefg}	55.3^{bcd}	71.2^{abc}	57.3^{abcd}	35.5^{c}	11.9^{c}	2.29^{efg}	4.00^{de}	41.38^{abc}	44.3^{a}
PR	Fitzroy	Tet	15.6^{ab}	81.1^{a}	82.5^{abc}	52.0^{cd}	38.5^{bc}	17.8^{bc}	10.5^{a}	40.1^{a}	40.7^{abc}	39.0^{abcd}
PR	Quartet	Tet	14.5^{abcde}	54.5^{bcd}	74.7^{abc}	53.1^{bcd}	37.1^{bc}	14.0^{bc}	2.43^{defg}	9.49^{bcde}	33.9^{abc}	36.7^{abcd}
Hybrid[2]	Fortimo	Tet	13.2^{bcdefg}	50.4^{bcd}	80.7^{abc}	59.3^{abcd}	37.3^{bc}	17.0^{bc}	1.16^{g}	7.78^{cde}	31.3^{bc}	41.7^{ab}
Hybrid	Storm	Tet	15.2^{abc}	51.1^{bcd}	72.8^{abc}	56.1^{abcd}	39.4^{abc}	14.3^{bc}	1.71^{fg}	5.63^{de}	27.7^{bc}	40.4^{abc}
Hybrid	Tirna	Tet	10.7^{gh}	54.9^{bcd}	67.4^{c}	50.7^{cd}	43.0^{abc}	15.4^{bc}	2.35^{efg}	7.57^{cde}	23.8^{c}	33.4^{bcde}
Hybrid	Solid	Tet	11.4^{fg}	52.3^{bcd}	67.9^{c}	52.2^{cd}	37.8^{bc}	17.5^{bc}	3.95^{cdef}	21.9^{b}	37.3^{abc}	31.8^{cde}
Festulolium[3]	Perseus	Tet	15.1^{abc}	60.3^{bc}	86.1^{a}	63.6^{a}	37.0^{bc}	21.9^{ab}	0.92^{g}	5.04^{de}	28.2^{bc}	30.2^{de}
Fescue[4]	Kora	Hex	8.00^{h}	40.3^{d}	68.2^{bc}	59.2^{abcd}	45.3^{abc}	27.8^{a}	6.79^{b}	19.2^{bc}	47.0^{ab}	25.1^{e}
LSD (0.05)			2.876	19.64	15.44	9.455	13.39	8.320	2.268	13.32	20.532	9.926

LSD (0.05) compares over cultivars within month

^{abc}Means with no common superscript differ significantly

[1]PR: Perennial ryegrass

[2]Hybrid: Perennial x Italian ryegrass hybrid

[3]Festulolium: Meadow fescue x Italian ryegrass hybrid

[4]Tall Fescue

Table 3: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial ryegrass, hybrid ryegrass, festulolium and fescue cultivars cultivars during year 2

Species	Cultivar	Ploidy	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
PR[1]	Alto	Dip	30.4^{a}	32.4^{abc}	16.1^{bcdef}	42.1^{abc}	20.3^{de}	33.5^{abcdef}	24.6^{bcd}	7.36^{bc}	13.7^{bcdefg}	14.3^{bcdef}	8.64^{cde}	9.08^{a}
PR	Bronsyn	Dip	28.1^{ab}	32.6^{ab}	18.0^{bcd}	38.4^{bcd}	21.2^{de}	28.4^{cdef}	25.3^{bc}	10.5^{b}	19.1^{abc}	17.6^{abc}	6.97^{de}	8.07^{abcd}
PR	Commando	Dip	26.2^{abc}	23.9^{cde}	11.7^{f}	35.3^{bcd}	24.9^{bcd}	32.4^{bcdef}	21.0^{cd}	7.17^{bc}	15.4^{bcdef}	14.4^{bcdef}	8.44^{cde}	8.39^{abc}
PR	Nui	Dip	29.5^{a}	33.8^{a}	17.8^{bcd}	39.5^{abcd}	17.4^{de}	26.0^{def}	22.6^{bcd}	9.10^{bc}	12.4^{cdefg}	11.5^{cdefg}	6.07^{e}	9.03^{a}
PR	Indiana	Dip	27.9^{ab}	28.5^{abcd}	13.8^{def}	39.9^{abcd}	23.7^{cd}	43.4^{a}	24.5^{bcd}	6.21^{bc}	17.0^{bcde}	19.3^{ab}	8.63^{cde}	8.81^{a}
PR	Bealy	Tet	25.1^{abcd}	26.3^{abcde}	17.7^{bcd}	33.7^{cd}	25.2^{bcd}	42.8^{a}	27.9^{ab}	17.0^{a}	21.4^{ab}	23.9^{a}	14.1^{ab}	10.5^{a}
PR	Sterling	Tet	21.0^{cde}	22.9^{def}	13.8^{def}	31.7^{cd}	20.1^{de}	29.4^{bcdef}	21.0^{cd}	6.78^{bc}	18.8^{abcd}	15.9^{bcde}	5.94^{e}	4.19^{e}
PR	Impresarrio	Tet	27.8^{ab}	30.1^{abcd}	16.6^{bcde}	40.5^{abc}	23.5^{cd}	35.1^{abcde}	22.5^{bcd}	7.20^{bc}	9.84^{efg}	11.9^{cdefg}	9.15^{cde}	8.58^{ab}
PR	Cheliac	Tet	22.8^{bcd}	24.4^{bcde}	15.3^{cdef}	33.0^{cd}	23.7^{cd}	31.2^{bcdef}	22.3^{bcd}	7.63^{bc}	15.2^{bcdefg}	11.3^{cdefg}	7.92^{cde}	3.83^{e}
PR	Polim	Tet	29.8^{a}	22.9^{def}	12.7^{ef}	41.0^{abc}	23.6^{cd}	37.2^{abc}	24.6^{bcd}	7.77^{bc}	14.7^{bcdefg}	20.6^{ab}	12.0^{abc}	8.63^{ab}
PR	Fitzroy	Tet	24.8^{abcd}	28.1^{abcd}	23.6^{a}	49.9^{a}	27.9^{abcd}	25.1^{ef}	22.7^{bcd}	7.97^{bc}	21.4^{ab}	17.2^{bcd}	7.77^{cde}	5.40^{cde}
PR	Quartet	Tet	25.7^{abcd}	28.8^{abcd}	16.8^{bcde}	29.6^{d}	12.6^{e}	24.6^{f}	18.6^{d}	7.27^{bc}	14.4^{bcdefg}	10.9^{defg}	5.57^{e}	5.62^{bcde}
Hybrid[2]	Fortimo	Tet	22.3^{bcd}	24.7^{bcde}	19.1^{bc}	37.5^{bcd}	32.4^{abc}	28.5^{cdef}	20.5^{cd}	4.49^{c}	7.54^{g}	9.17^{fg}	6.62^{de}	5.41^{cde}
Hybrid	Storm	Tet	29.8^{a}	26.8^{abcde}	19.7^{ab}	45.8^{ab}	34.7^{ab}	35.4^{abcd}	25.2^{bc}	5.84^{bc}	8.22^{fg}	9.94^{efg}	8.61^{cde}	8.36^{abc}
Hybrid	Tirna	Tet	25.1^{abcd}	23.4^{def}	17.4^{bcd}	36.7^{bcd}	32.9^{abc}	39.0^{ab}	27.5^{ab}	10.1^{bc}	18.1^{abcd}	15.1^{bcdef}	10.9^{abcd}	8.98^{a}
Hybrid	Solid	Tet	19.7^{de}	18.3^{ef}	16.4^{bcde}	32.2^{cd}	21.2^{de}	28.0^{cdef}	20.4^{cd}	9.00^{bc}	24.8^{a}	19.0^{ab}	9.92^{bcde}	5.30^{cde}
Festulolium[3]	Perseus	Tet	23.3^{bcd}	18.9^{ef}	19.8^{ab}	39.9^{abcd}	32.7^{abc}	26.6^{def}	21.8^{bcd}	9.22^{bc}	11.1^{defg}	7.53^{g}	7.02^{de}	5.00^{de}
Fescue[4]	Kora	Hex	15.6^{e}	15.1^{f}	18.5^{bc}	34.5^{cd}	35.7^{a}	36.0^{abcd}	31.9^{a}	18.0^{a}	21.4^{ab}	23.7^{a}	15.3^{a}	7.37^{abcd}
LSD (0.05)			6.214	8.600	4.360	10.92	10.50	10.01	6.340	6.020	7.746	6.515	4.534	3.118

LSD (0.05) compares over cultivars within month

^{abc}Means with no common superscript differ significantly

[1]PR: Perennial ryegrass

[2]Hybrid: Perennial x Italian ryegrass hybrid

[3]Festulolium: Meadow fescue x Italian ryegrass hybrid

[4]Tall Fescue

The total seasonal and annual DM production of perennial ryegrass, hybrid ryegrass , Festulolium and fescue cultivars during year 1 and year 2 is shown in Table 4 and Table 5, respectively. During year 1 the cultivar Fitzroy was the only cultivar that maintained a DM production that was the highest ($P<0.05$) or similar ($P>0.05$) to the highest producing cultivar during all seasons. The total annual DM production of Fitzroy was similar ($P>0.05$) to that of Alto, Bronsyn and Bealy, but higher ($P<0.05$) than the rest during year 1. During year 2 Bealy was the only cultivar that had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production throughout all seasons. Bealy had the highest ($P<0.05$) annual DM production during year 2, with similar ($P>0.05$) production from Alto, Bronsyn, Indiana, Impresarrio, Polim, Fitzroy, Storm, Tirna and the Fescue cultivar Kora.

Table 4: Total seasonal and annual dry matter production (kg DM ha^{-1}) of perennial ryegrass, hybrid ryegrass, festulolium and fescue cultivars cultivars during year 1

Species	**Cultivars**	**Ploidy**	**Winter**	**Spring**	**Summer**	**Autumn**	**Annual**
PR[1]	Alto	Dip	1272^{abcd}	6280^{abcd}	2347^{abc}	2468^{bcdef}	12367^{abcd}
PR	Bronsyn	Dip	1340^{ab}	6612^{abc}	1938^{bcde}	3076^{ab}	12966^{ab}
PR	Commando	Dip	930^{gh}	5653^{cde}	1813^{bcde}	2571^{bcd}	10966^{de}
PR	Nui	Dip	1411^{a}	5571^{de}	1887^{bcde}	1937^{def}	10806^{de}
PR	Indiana	Dip	1270^{abcd}	6150^{abcd}	2012^{bcde}	2391^{bcdef}	11823^{bcd}
PR	Bealy	Tet	1459^{a}	6450^{abcd}	2398^{ab}	2538^{bcde}	12844^{abc}
PR	Sterling	Tet	1020^{efg}	5859^{abcde}	1706^{de}	2821^{abc}	11405^{bcde}
PR	Impresarrio	Tet	1219^{abcdef}	6298^{abcd}	1825^{bcde}	2100^{cdef}	11441^{bcde}
PR	Cheliac	Tet	1038^{defg}	6155^{abcd}	2272^{abcd}	2089^{def}	11514^{bcde}
PR	Polim	Tet	1069^{cdefg}	5902^{abcde}	1642^{e}	2547^{bcde}	11160^{cde}
PR	Fitzroy	Tet	1344^{ab}	6484^{a}	2201^{abcde}	3354^{a}	13742^{a}
PR	Quartet	Tet	1246^{abcde}	5851^{abcde}	1778^{cde}	2268^{cdef}	11142^{cde}
Hybrid[2]	Fortimo	Tet	1131^{bcdefg}	6142^{abcd}	1870^{bcde}	2286^{cdef}	11429^{bcde}
Hybrid	Storm	Tet	1304^{abc}	5790^{bcde}	1840^{bcde}	2087^{def}	11021^{de}
Hybrid	Tirna	Tet	923^{gh}	5012^{e}	2011^{bcde}	1831^{ef}	9777^{e}
Hybrid	Solid	Tet	977^{fg}	5534^{de}	1982^{bcde}	2565^{bcd}	11058^{de}
Festulolium[3]	Perseus	Tet	1296^{abc}	6767^{ab}	2050^{bcde}	1798^{f}	11910^{bcd}
Fescue[4]	Fesc:Kora	Hex	688^{h}	5042^{e}	2705^{a}	2583^{bcd}	11019^{de}
LSD (0.05)			247.2	1016	608.2	728.2	1763

LSD (0.05) compares over cultivars within season

^{abc}Means with no common superscript differ significantly

[1]PR: Perennial ryegrass

[2]Hybrid: Perennial x Italian ryegrass hybrid

[3]Festulolium: Meadow fescue x Italian ryegrass hybrid

[4]Tall Fescue

Table 5: Total seasonal and annual dry matter production (kg DM ha^{-1}) of perennial ryegrass, hybrid ryegrass, festulolium and fescue cultivars cultivars during year 2

Species	Cultivars	Ploidy	Winter	Spring	Summer	Autumn	Annual
PR[1]	Alto	Dip	2399^{a}	2606^{abcde}	1472^{cde}	924^{cdefg}	7401^{abcde}
PR	Bronsyn	Dip	2393^{ab}	2395^{bcdef}	1825^{bc}	941^{cdef}	7554^{abcde}
PR	Commando	Dip	1880^{def}	2505^{abcde}	1413^{cde}	901^{cdefgh}	6699^{bcdef}
PR	Nui	Dip	2465^{a}	2265^{cdef}	1480^{cde}	781^{defghi}	6992^{bcdef}
PR	Indiana	Dip	2136^{abcde}	2881^{abc}	1503^{cde}	1055^{bcd}	7575^{abcde}
PR	Bealy	Tet	2092^{abcde}	2728^{abcde}	2324^{ab}	1377^{a}	8522^{a}
PR	Sterling	Tet	1751^{efg}	2198^{ef}	1493^{cde}	737^{efghi}	6180^{ef}
PR	Impresarrio	Tet	2258^{abcd}	2685^{abcde}	1297^{cde}	855^{defghi}	7094^{abcdef}
PR	Cheliac	Tet	1893^{def}	2378^{bcdef}	1468^{cde}	644^{fghi}	6383^{cdef}
PR	Polim	Tet	1980^{cdef}	2754^{abcde}	1523^{cde}	1169^{abc}	7426^{abcde}
PR	Fitzroy	Tet	2307^{abc}	2827^{abcde}	1679^{cd}	859^{defghi}	7672^{abcd}
PR	Quartet	Tet	2163^{abcd}	1812^{f}	1326^{cde}	634^{ghi}	5936^{f}
Hybrid[2]	Fortimo	Tet	1995^{bcdef}	2673^{abcde}	1024^{e}	606^{hi}	6299^{def}
Hybrid	Storm	Tet	2307^{abc}	3149^{a}	1246^{de}	778^{defghi}	7481^{abcde}
Hybrid	Tirna	Tet	1988^{cdef}	2929^{ab}	1833^{bc}	999^{bcde}	7749^{abc}
Hybrid	Solid	Tet	1637^{fg}	2207^{def}	1773^{cd}	960^{cde}	6578^{cdef}
Festulolium[3]	Perseus	Tet	1858^{defg}	2704^{abcde}	1426^{cde}	556^{i}	6544^{cdef}
Fescue[4]	Fesc:Kora	Hex	1470^{g}	2864^{abcd}	2491^{a}	1296^{ab}	8123^{ab}
LSD (0.05)			400.04	663.5	543.4	303.5	1447

LSD (0.05) compares over cultivars within season
[abc]Means with no common superscript differ significantly
[1]PR: Perennial ryegrass
[2]Hybrid: Perennial x Italian ryegrass hybrid
[3]Festulolium: Meadow fescue x Italian ryegrass hybrid
[4]Tall Fescue

The total annual DM production during year 1 and year 2, total DM production of year 1 and 2, the reduction in yield (kg DM ha^{-1}) from year 1 to 2, and the percentage reduction in yield from year 1 to 2 is shown in Table 6. The cultivars Alto, Bronsyn, Bealy and Fitzroy had the highest ($P<0.05$) or similar ($P>0.05$) to the highest annual dry matter production during both year 1 and year 2. Bronsyn, Bealy and Fitzroy were the only cultivars that had a yield above 20 tons for the two years. The ryegrass hybrid Tirna and Fescue cultivar Kora were either the lowest or similar ($P>0.05$) to the lowest yielding cultivar during year 1, but had a similar ($P>0.05$) yield to the highest yielding cultivar (Bealy) during year 2. Aside from these two cultivars all other cultivars showed reduction in yield of above 30%, with the highest reduction in yield 47%.

Table 6: The annual dry matter production during year 1 and 2 (kg DM ha^{-1}), total production over two years (kg DM ha^{-1}), reduction in yield from year 1 to 2 (kg DM ha^{-1}) and the percentage reduction from year 1 to two of perennial ryegrass, hybrid ryegrass, festulolium and fescue cultivars

Species	Cultivars	Ploidy	Year 1	Year 2	Total over two years	Reduction in yield	% Reduction in yield
PR[1]	Alto	Dip	12367[abcd]	7401[abcde]	19768	4966	40
PR	Bronsyn	Dip	12966[ab]	7554[abcde]	20520	5412	42
PR	Commando	Dip	10966[de]	6699[bcdef]	17665	4267	39
PR	Nui	Dip	10806[de]	6992[bcdef]	17798	3814	36
PR	Indiana	Dip	11823[bcd]	7575[abcde]	19398	4248	36
PR	Bealy	Tet	12844[abc]	8522[a]	21366	4322	34
PR	Sterling	Tet	11405[bcde]	6180[ef]	17585	5225	46
PR	Impresarrio	Tet	11441[bcde]	7094[abcdef]	18535	4347	38
PR	Cheliac	Tet	11514[bcde]	6383[cdef]	17897	5131	45
PR	Polim	Tet	11160[cde]	7426[abcde]	18586	3734	34
PR	Fitzroy	Tet	13742[a]	7672[abcd]	21414	6070	44
PR	Quartet	Tet	11142[cde]	5936[f]	17078	5206	47
Hybrid[2]	Fortimo	Tet	11429[bcde]	6299[def]	17728	5130	45
Hybrid	Storm	Tet	11021[de]	7481[abcde]	18502	3540	32
Hybrid	Tirna	Tet	9777[e]	7749[abc]	17526	2028	21
Hybrid	Solid	Tet	11058[de]	6578[cdef]	17636	4480	41
Festulolium[3]	Perseus	Tet	11910[bcd]	6544[cdef]	18454	5366	45
Fescue[4]	Fesc:Kora	Hex	11019[de]	8123[ab]	19142	2896	26
		LSD (0.05)	1763	1447			

[1]PR: Perennial ryegrass
[2]Hybrid: Perennial x Italian ryegrass hybrid
[3]Festulolium: Meadow fescue x Italian ryegrass hybrid
[4]Tall Fescue

Conclusions

1. The perennial ryegrass cultivars Bealy, Bronsyn and Fitzroy had the highest annual dry matter production during year one and year two.
2. The hybrid ryegrass Tirna and tall fescue cultivar Kora had a similar yield to Bealy during year two, and showed the lowest decline in yield from year 1 to year 2.
3. The persistence of perennial grasses should be considered along with production potential when deciding on which cultivar or variety to utilise.

Message to the farmer

The production potential of perennial ryegrass declines after the first year of production.

The selection of a perennial grass for inclusion in a system should be based on seasonal production potential and the persistence of the species/cultivar over years.

References

Ammann SHD and Goodenough D 2006. Italian and Westerwolds ryegrass varieties for the Southern Cape: Outeniqua trial results. Outeniqua Research Farm Information day booklet 2008. pp 9

Botha PR 2002. Die gebruik van vogspanningmeters vir besproeiingskedulering by weidings. Weidingskursus 2002. Inligtingsbundel Suid-Kaap Landbou-ontwikkelingsentrum. Departement Landbou Wes-Kaap. pp 141-149.

Botha PR 2008. Faktore wat die volhoubaarheid vna klawer in 'n gras-klawerweiding beïnvloed. Outeniqua Navorsingsplaas Weidingskursusbundel 2008. pp 86 – 90

Botha PR and Gerber HS. 2008. The annual production and botanical composition of perennial ryegrass, Tall fescue, Cocksfoot and clovers over-sown with annual or perennial ryegrass. Outeniqua Research Farm Information day booklet 2008. pp 22, 24.

Botha PR, Gerber HS, Zulu LB. 2008. Die seisoenale droëmateriaalproduksie van Kropaargras, Swenkgras en verskillende meer- en eenjarige raaigrasspesies. Outeniqua Navorsingsplaas Inligtingsdag bundel 2008. pp 12.

Donaldson CH. 2001. A practical guide to planted pastures. Chapter 4, pp 35.

Ott RL. 1998. An Introduction to Statistical methods and data analysis. Belmont, California: Duxbury Press. pp 807-837.

SAS Institute, Inc. 2008. SAS Version 9.2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Shapiro SS and Wilk MB. 1965. An Analysis of Variance Test for Normality (complete samples). Biometrika. 52, 591-611.

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

THE EVALUATION OF PERENNIAL LEGUME CULTIVARS IN THE SOUTHERN CAPE

J. van der Colf[1] & PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

Grain and forage legumes occupy 12 to 15% of the Earth's arable land (Graham and Vance 2003). Mixed pastures containing legumes have the advantage over grass pastures in that they are often of high quality and add N the cropping system (Brock and Hay 2001, Graham and Vance 2003, Dahlin and Stenberg 2010). Biologically fixed nitrogen is derived from solar energy, whereas N fertilizer requires significant amounts of fossil fuels and other commercial energy sources to produce, with perennial legumes the most economical way of decreasing the reliance on these expensive sources of inorganic nitrogen (Neal et al. 2009). The inclusion of perennial legumes and grasses is thus the most likely base whereby to improve the sustainability and long term survival of pasture systems (Cransberg and McFarlane 1994). Clovers and trefoil are some of the most important forage legumes worldwide (Graham and Vance 2003). The variation in the spread of seasonal production between different cultivars and species, accompanied by the broad range of genetic resources available, necessitates the evaluation of different cultivars of perennial clovers and trefoil under the local climatic and environmental conditions of the Western Cape. The aim of this study was to evaluate and compare the production potential of different perennial legumes such as white clover, red clover, strawberry clover and birdsfoot trefoil.

Materials and Methods

The study was carried out on the Outeniqua Research farm near George (Altitude 201 m, 33° 58' 38" S and 22° 25' 16" E, rainfall 728 mm year^{-1}) in the Western Cape of South Africa on an Witfontein soil form (Soil Classification Workgroup 1991). The study area was under permanent overhead sprinkler irrigation, with irrigation scheduling undertaken by means of a tensiometer. Irrigation commenced at a tensiometer reading of -25 kPa and was terminated at a reading of -10 kPa (Botha 2002).

Soil samples were taken prior to establishment to a depth of 150mm and analysed for Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S, and C levels. Fertiliser was applied according to the soil analysis to raise soil P level to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and pH (KCl) to 5.5 (Beyers 1973).

The species that were evaluated include white clover (*Trifolium repens*), red clover (*Trifolium pratense*), Strawberry clover (*Trifolium fragiferum*) and Birdsfoot trefoil (*Lotus corniculatis*). A total of 18 cultivars were evaluated in the form of a randomized block design, with three replicates per cultivar (total of 54 plots). The scientific name, common name, cultivar name and seeding rate of the perennial legumes that were evaluated are given in Table 1.

The trial was established on the 5th of May 2011 on a paddock previously planted to perennial ryegrass-clover pastures. The paddock was sprayed with herbicide during January and tilled during February to remove the existing sward. Three subsequent herbicide applications (up to establishment) were aimed at eradication of emerging weeds. Prior to establishment the trial area was tilled with a disk harrow and kongskilde and rolled with a light landroller to create a firm seedbed and eradicate any remaining weeds.

Table 1: The scientific name, common name, cultivar name and seeding rate of perennial legumes that were evaluated during the study

	Scientific name	**Common name**	**Cultivar name**	**Seeding rate (kg ha^{-1})**
1	*Trifolium repens*	White clover	Haifa	6
2	*Trifolium repens*	White clover	Huia	6
3	*Trifolium repens*	White clover	Agrimatt	6
4	*Trifolium repens*	White clover	Agridan	6
5	*Trifolium repens*	White clover	Riesling	6
6	*Trifolium repens*	White clover	Dusi	6
7	*Trifolium repens*	White clover	Klondike	6
8	*Trifolium repens*	White clover	Alice	6
9	*Trifolium pratense*	Red clover	Quinequeli	8
10	*Trifolium pratense*	Red clover	Tropero	8
11	*Trifolium pratense*	Red clover	Amos	8
12	*Trifolium pratense*	Red clover	Red gold	8
13	*Trifolium pratense*	Red clover	Kenland	8
14	*Trifolium pratense*	Red clover	Suez	8
15	*Trifolium pratense*	Red clover	Rajah	8
16	*Trifolium pratense*	Red clover	Lemmon	8
17	*Lotus corniculatis*	Trefoil	Sao Gabriel	5
18	*Trifolium fragiferum*	Strawberry clover	Palestine	6

The various cultivars/species were planted according to commercially recommended seeding rates and adapted for germination percentages. Plots were 2.1 m x 6 m per treatment (12.6 m^2), with 14 rows that were 15 cm apart. All seed was inoculated with species specific *Rhizobium* a maximum of 2 hours before planting and kept in a cool place until it could be planted. Seed was also treated with pesticide and fungicide prior to establishment. Immediately after establishment, each plot was raked lightly to cover seeds and maintain inoculant activity.

Plots were harvested using quadrats every 28 days to determine growth rate (kg DM ha^{-1} day^{-1}) and dry matter (DM) production (kg DM ha^{-1}). Three quadrats of 0.25 m^2 were randomly placed per plot and cut to a height of 50 mm. The samples were pooled and weighed. A grab sample of approximately 500g green material was taken from the pooled sample, weighed, dried at 60°C for 72 hours and weighed to determine DM content. After sampling plots were cut to a uniform height of 50 mm above ground level using a Honda Lawnmower. Plots were only fertilised when deficiency symptoms become apparent or if deficiencies were identified in the soil analysis. Weed control was exercised mainly by mechanical means.

A Student LSD (least significant difference) at 5 % significance level was performed to compare the treatment means (Ott 1998). The STATS module of SAS version 9.2 (2008) was used to analyze the data. Data from various cultivars were also combined according to species to determine the mean production of the different species.

Results and discussion

Comparison of species

The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial legume species during year 1 is shown in Table 2. White clover had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate during all months except January. Red clover had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate from August to December, but the lowest ($P<0.05$) or similar ($P>0.05$) to the lowest growth rate from March to May.

Table 2 The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial legumes during year 1

Species	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
White clover	5.81^{a}	50.1^{a}	60.6$_{ab}$	51.1^{a}	67.0^{a}	13.7^{b}	5.29^{a}	26.4^{a}	26.4^{a}	25.0^{a}
Red clover	4.31^{a}	52.1^{a}	65.9^{a}	47.7^{a}	79.8^{a}	9.82^{b}	3.61^{a}	3.76^{c}	2.62^{c}	3.53^{c}
Trefoil	1.27^{b}	28.3^{b}	51.3^{bc}	46.7^{a}	79.0^{a}	40.3^{a}	3.13^{a}	6.26^{c}	0.85^{c}	-
Strawberry clover	3.25^{ab}	45.4^{a}	46.1^{c}	16.6^{b}	84.2^{a}	10.0^{b}	1.69^{a}	17.0^{b}	14.9^{b}	15.7^{b}
LSD (0.05)	2.736	15.41	10.74	11.93	19.8	9.333	4.511	6.387	5.978	5.621

LSD (0.05) compares over species within months
^{abc}Means with no common superscript differ significantly

The total seasonal and annual dry matter (DM) production (kg DM ha^{-1}) of perennial legume species during year 1 is shown in Table 3. The autumn and total annual DM production of white clover was the highest ($P<0.05$) of the perennial legumes. Red clover, trefoil and strawberry clover had similar ($P>0.05$) total annual DM production, but it was lower ($P<0.05$) than that of white clover.

Table 3: Total seasonal and annual production (kg DM ha^{-1}) of perennial legumes during year 1

Species	**Winter**	**Spring**	**Summer**	**Autumn**	**Annual**
White clover	645^{a}	4590^{a}	2438^{b}	2178^{a}	9850^{a}
Red clover	478^{a}	4704^{a}	2734^{b}	239^{c}	8154^{b}
Trefoil	141^{b}	3589^{b}	3648^{a}	191^{c}	7521^{b}
Strawberry clover	361^{ab}	3071^{b}	2815^{b}	1175^{b}	7422^{b}
LSD (0.05)	303.6	784.7	790.6	345.7	1333

LSD (0.05) compares over species within season
^{abc}Means with no common superscript differ significantly

Comparison of cultivars

The mean monthly growth rate of perennial legume cultivars during year 1 is shown in Table 4. The white clover cultivar Dusi and red clover cultivars Tropero, Suez and Rajah had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate from August to December. From January to May all the red clover cultivars had the lowest ($P<0.05$) or similar to the lowest growth rate.

The total seasonal and annual DM production of perennial legume cultivars during year 1 is shown in Table 5. The white clover cultivar Dusi and red clover cultivars Kenland, Suez and Rajah had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production from winter to summer. During autumn all the red clover cultivars had the lowest ($P<0.05$) DM production. The white clover cultivar Dusi had a similar ($P>0.05$) annual DM to Huia, Agrimatt, Agridan, Riesling and Alice, but higher ($P<0.05$) than the rest. Amos had a lower total annual dry matter procution than the other red clover cultivars. The remaining red clover cultivars, strawberry clover and trefoil had similar ($P>0.05$) total annual DM productions.

Conlcusions

1. The red clover cultivars Tropero, Suez and Rajah had high growth rates from August to December, but showed a mark decline in growth from January to May.
2. The white clover cultivars Dusi had the highest annual dry matter production and also maintained a high growth rate from August to December. Data from successive years will be required to determine the persistence of various white clover cultivars.
3. White and red clover had the same production from winter to early summer, but red clover production declined from late summer to autumn.
4. Red clover had a high productivity during its first growth season, after which productivity was found to decline. Due to the ability of white clover to remain productive during autumn, it achieved a higher total annual dry matter production than red clover
5. The majority of white clover cultivars showed a higher persistence than red clover. If planted in mixtures the early growth of red clover and persistence of white clover could complement each other in the fodder flow program.

Message to the Farmer

The white clover cultivar Dusi had the highest total annual dry matter production, but it was similar to that of Huia, Agrimatt, Agridan, Riesling and Alice.

The poor persistence of red clover indicates that its growth pattern represents that of an annual in this region.

The selection of complementary species and cultivars can improve fodder flow.

Table 4: The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial legume cultivars during year 1

Species	Cultivar	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
WC	Haifa	6.83^{a}	37.1^{fgh}	55.9^{defg}	44.4^{bc}	75.7^{abcd}	9.43^{bcd}	3.31^{bcd}	21.6^{bc}	20.9^{de}	21.4^{ab}
WC	Huia	3.89^{abcde}	49.8^{abcdef}	56.6^{defg}	52.1^{abc}	59.3^{cd}	14.5^{bcd}	7.70^{ab}	33.9^{a}	22.8^{cd}	26.6^{a}
WC	Agrimatt	5.95^{abcd}	42.2^{efg}	57.2^{defg}	50.8^{abc}	61.9^{bcd}	19.0^{b}	5.61^{bcd}	24.7^{bc}	34.0^{a}	24.9^{ab}
WC	Agridan	6.51^{ab}	45.9^{cdef}	64.0^{bcde}	46.0^{bc}	78.1^{abcd}	13.9^{bcd}	11.9^{a}	27.6^{ab}	25.0^{cd}	25.5^{ab}
WC	Riesling	5.18^{abcd}	49.1^{abcdef}	60.3^{cdef}	54.0^{ab}	62.4^{bcd}	17.6^{bc}	2.31^{cd}	22.0^{bc}	27.5^{bc}	25.7^{a}
WC	Dusi	6.78^{a}	60.7^{ab}	77.6^{a}	62.1^{a}	74.7^{abcd}	14.9^{bcd}	4.20^{bcd}	26.0^{b}	23.1^{cd}	19.6^{ab}
WC	Kolndike	5.04^{abcd}	56.0^{abcde}	52.8^{efg}	43.3^{bc}	57.5^{d}	2.56^{d}	2.00^{cd}	27.4^{ab}	26.4^{bcd}	28.1^{a}
WC	Alice	6.32^{abc}	59.7^{abc}	61.6^{bcdef}	55.6^{ab}	66.4^{bcd}	16.5^{bcd}	6.61^{bc}	28.2^{ab}	31.2^{ab}	27.9^{a}
RC	Quineiqueli	2.96^{cde}	61.3^{ab}	65.0^{bcd}	37.7^{c}	82.1^{abcd}	8.60^{bcd}	3.07^{bcd}	2.53^{d}	2.74^{f}	3.95^{d}
RC	Tropero	5.400^{abcd}	59.1^{abcd}	71.1^{abc}	51.9^{abc}	73.1^{abcd}	6.65^{bcd}	3.30^{bcd}	3.52^{d}	2.70^{f}	6.06^{cd}
RC	Amos	2.72^{de}	23.0^{h}	58.9^{def}	38.0^{c}	62.3^{bcd}	3.89^{cd}	1.11^{d}	-	-	0.37^{d}
RC	Red gold	5.82^{abcd}	63.2^{a}	58.0^{def}	47.8^{abc}	76.0^{abcd}	7.68^{bcd}	4.88^{bcd}	2.78^{d}	2.61^{f}	4.27^{d}
RC	Kenland	5.05^{abcd}	58.9^{abcd}	65.1^{bcd}	51.2^{abc}	87.9^{ab}	12.6^{bcd}	5.22^{bcd}	4.69^{d}	3.11^{f}	4.23^{d}
RC	Suez	3.58^{abcde}	53.5^{abcde}	71.3^{abc}	53.6^{ab}	99.0^{a}	9.67^{bcd}	1.30^{d}	1.61^{d}	0.49^{f}	0.76^{d}
RC	Rajah	3.71^{abcde}	48.9^{abcdef}	72.5^{ab}	53.1^{ab}	80.2^{abcd}	14.1^{bcd}	2.85^{bcd}	4.59^{d}	2.72^{f}	2.47^{d}
RC	Lemmon	5.21^{abcd}	48.6^{bcdef}	64.9^{bcd}	48.5^{abc}	77.8^{abcd}	15.4^{bcd}	6.02^{bcd}	5.06^{d}	3.95^{f}	4.44^{d}
Trefoil	Soa Gabriel	3.25^{bcde}	28.3^{gh}	51.3^{fg}	46.7^{bc}	79.0^{abcd}	40.3^{a}	3.13^{bcd}	6.26^{d}	0.85^{f}	-
SC	Palestine	1.27^{e}	45.4^{def}	46.1^{g}	16.6^{d}	84.2^{abc}	10.0^{bcd}	1.69^{cd}	17.0^{c}	14.9^{e}	15.7^{bc}
		3.435	14.28	11.89	15.04	26.41	13.96	5.078	7.788	6.115	9.821

WC: white clover

RC: Red clover

SC: Strawberry clover

LSD (0.05) compares over cultivars within months

^{abc}Means with no common superscript differ significantly

Table 5: Total seasonal and annual dry matter production (kg DM ha^{-1}) of perennial legume cultivars during year 1

Species	Cultivar	Winter	Spring	Summer	Autumn	Annual
WC	Haifa	758[a]	3879[fgh]	2502[bcd]	1790[c]	8930[bcde]
WC	Huia	432[abcde]	4495[bcdef]	2432[bcd]	2332[ab]	9690[abcd]
WC	Agrimatt	660[abcd]	4263[efg]	2319[bcd]	2341[ab]	9583[abcd]
WC	Agridan	722[ab]	4428[cdef]	2965[abc]	2187[abc]	10302[abc]
WC	Riesling	575[abcd]	4636[bcde]	2233[bcd]	2107[abc]	9550[abcd]
WC	Dusi	752[a]	5690[a]	2778[abcd]	1925[bc]	11145[a]
WC	Kolndike	560[abcd]	4313[defg]	1785[d]	2294[ab]	8952[bcde]
WC	Alice	702[abc]	5016[abcd]	2488[bcd]	2444[a]	10649[ab]
RC	Quineiqueli	329[cde]	4657[bcde]	2754[abcde]	258[e]	7999[de]
RC	Tropero	599[abcd]	5168[ab]	2437[bcd]	311[e]	8515[cde]
RC	Amos	302[de]	3415[hi]	1955[cd]	10.5[e]	5678[f]
RC	Red gold	646[abcd]	4792[bcde]	2605[abcd]	230[e]	8273[de]
RC	Kenland	560[abcd]	4971[abcde]	3119[ab]	337[e]	8986[bcde]
RC	Suez	398[abcde]	5068[abc]	3222[ab]	43.0[e]	8730[cde]
RC	Rajah	412[abcde]	4962[abcde]	2839[abc]	274[e]	8486[cde]
RC	Lemmon	579[abcd]	4601[bcdef]	2939[abc]	376[e]	8494[cde]
Trefoil	Soa Gabriel	141[e]	3589[ghi]	3648[a]	191[e]	7521[ef]
SC	Palestine	361[bcde]	3071[i]	2815[abcd]	1175[d]	7422[ef]
LSD (0.05)		381.2	733.5	1053	435.9	1897

WC: white clover

RC: Red clover

SC: Strawberry clover

LSD (0.05) compares over cultivars within season

[abc]Means with no common superscript differ significantly

References

Beyers CP. 1973. Bemesting van aangeplante wiedings. *Winterreën Spesiale Uitgawe* 5, 54-59.

Botha PR. 2002. Die gebruik van vogspanningmeters vir besproeiingskedulering by weidings. *Weidingskursus Inligtingsbundel 2002*. Suid Kaap Landbou-ontwikkelinsentrum, Departement Landbou Wes-Kaap. pp 141-149.

Brock JL, Hay MJM. 2001. White clover performance in sown pastures: A biological/ecological perspective. Proceedings of the New Zealand Grassland Association 63. Pp. 73-83.

Cransberg L, McFarlane DJ. 1994. Can perennial pastures provide the basis for a sustainable farming system in Southern Australia? New Zealand Journal of Agricultural Research. 37:287-294.

Dahlin AS, Stenberg M. 2010. Transfer of N from red clover toe perennial ryegrass in mixed stands under different cutting strategies. European Journal of Agronomy. doi:10.1016/j.eja.2010.04.006.

Graham PH, Vance CP. 2003. Legumes: Importance and constraints to greater use. Plant Physiology. 131: 872-877.

Neal JS, Fulkerson WJ, Lawrie R, Barchia LM. 2009. Difference in yield and persistence among perennial forages used by the dairy industry under optimum and deficit irrigation. Crop & Pasture Science. 60:1071-1087.

Ott RL. (1998) An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051)

Soil Classification Workgroup. 1991. Soil Classification, a Taxonomic system for South Africa. Memoirs on the Natural Agricultural Resources of South Africa. Nr 15. Department of Agricultural Development, Pretoria.

THE EVALUATION OF TEMPERATE PERENNIAL GRASS CULTIVARS IN THE SOUTHERN CAPE: TALL FESCUE, MEADOW FESCUE, COCKSFOOT, PERENNIAL RYEGRASS AND *BROMUS* SPP.

J van der Colf[1] & PR Botha[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

Pastures in the main milk producing regions of the southern Cape are primarily based on kikuyu over-sown with annual or perennial ryegrass. Although these pastures can maintain production rates of between 15 and 18 t DM ha^{-1} annum^{-1} (Van der Colf 2010), both annual and perennial ryegrass display poor persistence and must be re-established by over-sowing ryegrass on an annual basis during autumn (Botha et al. 2003, Botha et al. 2008). Tall Fescue (*Festuca arundinacea*), Cocksfoot (*Dactylis glomerata*) and *Bromus* spp. are alternative temperate perennial grasses that could improve the persistence and stress tolerance (Reed 1996, Callow et al. 2003, Nie et al. 2008) of the temperate grass component within kikuyu systems. There is, however, limited data available on the production potential and forage quality of the most recent cultivars of these species under irrigation in the Southern Cape. The aim of this study was to evaluate the production potential of various cultivars of temperate perennial grasses. The study will be carried out over a period of three years, but only the first year of data will be presented here.

Materials and methods

The study was carried out on the Outeniqua Research Farm near George (Altitude 201 m, 33° 58' 38'' S and 22° 25' 16'' E, rainfall 728 mm year^{-1}) in the Western Cape of South Africa on a Witfontein soil form (Soil Classification Workgroup, 1991). The study area is under permanent overhead sprinkler irrigation, with irrigation scheduling undertaken by means of a tensiometer. Irrigation will commence at a tensiometer reading of -25 kPa and will be terminated at a reading of -10 kPa (Botha 2002).

Prior to establishment soil samples were taken to a depth of 150 mm and analysed for Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S, and C levels. Fertiliser was applied according to the soil analysis to raise soil P level to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and pH (KCl) to 5.5 (Beyers 1973).

The species being evaluated include Tall Fescue (*Festuca arundinacea*), Meadow Fescue (*Festuca pratensis*), Chewings Fescue (*Festuca rubra* subsp. *commutata*), Red Fescue (*Festuca rubra*), Cocksfoot (*Dactylis glomerata*), Perennial ryegrass (*Lolium perenne*) and two Bromus species (*Bromus catharticus* and *B. parodii*). A total of 38 cultivars are being evaluated in the form of a randomized plot design, with three replicates per cultivar. The scientific name, common name cultivar name and seeding rate of the species that were evaluated are given in Table 1.

Table 1: The scientific name, common name cultivar name and seeding rate (kg ha^{-1}) of species evaluated during the study

	Scientific name	Common name	Cultivar name	Seeding rate
1	*Festuca arundinacea*	Tall Fescue	Kora	20
2	*Festuca arundinacea*	Tall Fescue	Tuscany	20
3	*Festuca arundinacea*	Tall Fescue	Barlite	20
4	*Festuca arundinacea*	Tall Fescue	Verdant	20
5	*Festuca arundinacea*	Tall Fescue	Jenna	20
6	*Festuca arundinacea*	Tall Fescue	KR5605	20
7	*Festuca arundinacea*	Tall Fescue	GFM24	20
8	*Festuca arundinacea*	Tall Fescue	Cochise	20
9	*Festuca arundinacea*	Tall Fescue	Sidewinder	20
10	*Festuca arundinacea*	Tall Fescue	GFM29	20
11	*Festuca arundinacea*	Tall Fescue	Bronson forage	20
12	*Festuca arundinacea*	Tall Fescue	Baroptima	20
13	*Festuca arundinacea*	Tall Fescue	Bariane	20
14	*Festuca arundinacea*	Tall Fescue	Barverde	20
15	*Festuca arundinacea*	Tall Fescue	Boschoek	20
16	*Festuca arundinacea*	Tall Fescue	Advance	20
17	*Festuca pratensis*	Meadow Fescue	Laura	20
18	*Festuca pratensis*	Meadow Fescue	Jamaica	20
19	*Festuca rubra* sub. *commuta*	Chewings Fescue	Rushmore	20
20	*Festuca rubra*	Red fescue	Gibralter	20
21	*Dactylis glomerata*	Cocksfoot	Athos	15
22	*Dactylis glomerata*	Cocksfoot	Sparta	15
23	*Dactylis glomerata*	Cocksfoot	Niva	15
24	*Dactylis glomerata*	Cocksfoot	Cristobal	15
25	*Dactylis glomerata*	Cocksfoot	Adremo	15
26	*Dactylis glomerata*	Cocksfoot	Barvillo	15
27	*Dactylis glomerata*	Cocksfoot	Barexcel	15
28	*Dactylis glomerata*	Cocksfoot	Oxen	15
29	*Dactylis glomerata*	Cocksfoot	Hera	15
30	*Dactylis glomerata*	Cocksfoot	Wana	15
31	*Dactylis glomerata*	Cocksfoot	Pizza	15
32	*Lolium perenne*	Perennial ryegrass	Bealy	20
33	*Lolium perenne*	Perennial ryegrass	Trojan	20
34	*Lolium perenne*	Perennial ryegrass	Arrow	20
35	*Lolium perenne*	Perennial ryegrass	Bronsyn	20
36	*Lolium perenne*	Perennial ryegrass	Remington	20
37	*Bromus catharticus*		Ceres Atom	20
38	*Bromus parodii*		GBP02	20

The trial was established on the 5th of May 2011 on a paddock previously planted to perennial ryegrass-clover pastures. The paddock was sprayed with herbicide during January and tilled during February to remove the existing sward. Three subsequent herbicide applications (up to establishment) were aimed at eradication of emerging weeds. Prior to establishment the trial area was tilled with a disk harrow and kongskilde and rolled with a light landroller to create a firm seedbed and eradicate any remaining weeds. The various cultivars/species were planted according to commercially recommended seeding rates and adapted for germination percentages. Plots were 2.1 m x 6 m per treatment (12.6 m^2), with 14 rows that were 15 cm apart. After establishment plots were raked lightly to cover seeds.

Plots were harvested every 28 days using quadrats to determine growth rate (kg DM ha^{-1} day^{-1}) and total dry matter production (kg DM ha^{-1}). Three quadrats of 0.25 m^2 were randomly placed per plot and cut to a height of 50 mm above ground level. The samples were pooled and weighed. A grab sample of approximately 500g green material was taken from the pooled sample, weighed, dried at 60°C for 72 hours and weighed to determine DM content. After sampling plots were cut to a uniform height of 50 mm using a Honda Lawnmower. All plots receive a topdressing of 50 kg N ha^{-1} and 50 kg K ha^{-1} after each harvest (ARC, 2005).

A Student least significant difference (LSD) at 5 % significance level was performed to compare the treatment means (Ott 1998). The STATS module of SAS version 9.2 (2008) was used to analyze the data. Data was also combined within species to compare the production potential of the various species and analyzed within species to compare the production potential of different cultivars within the species Cocksfoot and Fescue.

Results and discussion

Species compared

The mean monthly growth rate of perennial ryegrass, Fescue, Cocksfoot and *Bromus* during year 1 is given in Table 2. *Bromus* had the highest ($P<0.05$) or similar to the highest growth rate during all months except April.

Since perennial ryegrass is the most widely used temperate perennial grass species in the southern Cape, it will be used as a reference species. From July to November the growth rate of perennial ryegrass was the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate. Cocksfoot had a lower ($P<0.05$) growth rate than perennial ryegrass from July to September but a similar ($P>0.05$) or higher ($P<0.05$) growth rate than perennial ryegrass from October to May. Fescue had a lower ($P<0.05$) growth rate than perennial ryegrass from July to October, but a similar ($P>0.05$) growth rate from November to May. *Bromus* had a similar ($P>0.05$) growth rate to perennial ryegrass from July to November, but higher ($P<0.05$) than perennial ryegrass from December to March

Table 2: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial ryegrass, Fescue, Cocksfoot and *Bromus* during year 1

Species	July*	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Perennial ryegrass	4.62^{a}	24.9^{a}	62.8^{a}	113^{a}	79.0^{ab}	56.3^{c}	48.4^{b}	34.9^{b}	38.1^{b}	49.3^{a}	27.9^{ab}
Fescue	1.63^{b}	10.0^{b}	40.5^{b}	94.3^{b}	67.8^{b}	53.9^{c}	56.9^{b}	34.3^{b}	44.8^{ab}	48.8^{a}	29.1^{a}
Cocksfoot	0.86^{b}	9.68^{b}	46.7^{b}	106^{ab}	81.7^{a}	78.0^{b}	53.3^{b}	37.9^{ab}	46.6^{a}	44.5^{ab}	23.3^{b}
Bromus	3.48^{a}	22.1^{a}	72.6^{a}	118^{a}	89.2^{a}	103^{a}	68.9^{a}	41.0^{a}	51.6^{a}	40.6^{b}	26.7^{ab}
LSD (0.05)	1.179	5.900	12.61	17.43	11.29	10.04	11.03	5.581	7.501	6.701	5.057

LSD (0.05) compares over species within months

^{abc}Means with no common superscript differ significantly

*Growth rate from establishment to first harvest

The total seasonal and annual dry matter (DM) production of perennial ryegrass, Fescue, Cocksfoot and *Bromus* during year 1 is given in Table 3. *Bromus* had the highest ($P<0.05$) or similar ($P>0.05$) to the highest DM production during all seasons and also had the highest ($P<0.05$) total annual DM production. The seasonal DM production of perennial ryegrass was higher ($P<0.05$) than that of Cocksfoot and Fescue during winter, but similar ($P>0.05$) during spring and autumn. During summer the DM production of Cocksfoot was higher ($P<0.05$) than for perennial ryegrass. The total annual DM production of perennial ryegrass was similar ($P>0.05$) to that of Cocksfoot, but higher ($P<0.05$) than for Fescue. Cocksfoot and Fescue had a similar ($P>0.05$) total annual DM production.

Table 3: Total seasonal and annual dry matter production (kg DM ha^{-1}) of perennial ryegrass, fescue, cocksfoot and Bromus

Species	Winter	Spring	Summer	Autumn	Annual
Perennial ryegrass	1192^{a}	7283^{ab}	4030^{c}	3195^{a}	15701^{b}
Fescue	423^{b}	5952^{b}	4269^{bc}	3411^{a}	14055^{c}
Cocksfoot	363^{b}	6949^{b}	4817^{b}	3184^{a}	15312^{bc}
Bromus	991^{a}	8219^{a}	6207^{a}	3326^{a}	18744^{a}
LSD (0.05)	276.5	953.1	569.1	381.5	1572

LSD (0.05) compares within season and over species.

^{abc}Means with no common superscript differ significantly

Bromus was the only species that could maintain a high production throughout all seasons and that had a higher ($P<0.05$) annual DM production than perennial ryegrass. Perennial ryegrass had a higher ($P<0.05$) production than Cocksfoot and Fescue during early establishment or winter, but from spring onwards the production of perennial ryegrass was either similar ($P>0.05$) to or lower ($P<0.05$) than these species. A second year of data will clarify whether the slower establishing Cocksfoot and Fescue can obtain higher production and improved persistence compared to perennial ryegrass from year 2 onwards. The persistence of *Bromus* also remains to be seen.

Fescue cultivars compared

The mean monthly growth rate of Fescue cultivars during year 1 is shown in Table 4. The highest growth rate was obtained by different cultivars during different months. Verdant was the only cultivar that had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate during all months from July to November. However, during December, February, April and May the growth rate of Verdant was lower ($P<0.05$) than the highest growth rate. The cultivars Tuscany and Bariane maintained the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate from October to May.

The total seasonal and annual DM production of fescue cultivars during year 1 is given in Table 5. Verdant had the highest ($P<0.05$) seasonal production winter. The cultivars Tuscany, Barlite, Jenna, KR6506, Bronson Forage, Baropitima and Bariane had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production during all seasons from spring to autumn. Bariane had the highest ($P<0.05$) annual DM production, with similar ($P>0.05$) productions from Kora, Tuscany, Barlite, Verdant, Jenna, KR6506, Bronson Forage, Baropitima, Boschoek and Advance.

Cocksfoot cultivars compared

The mean monthly growth rate of cocksfoot cultivars during year 1 is shown in Table 6. The highest ($P<0.05$) growth rate was obtained by different cultivars during different months.

The total seasonal and annual DM production of cocksfoot cultivars is given in Table 7. Athos, Cristobal and Oxen had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production during all seasons. The cultivars Cristobal and Adremo had the highest ($P<0.05$) total annual DM production, with similar ($P>0.05$) production achieved by Athos, Barvillo and Oxen.

All cultivars compared

The monthly growth rate of temperate perennial grasses during year one is shown in Table 8. The perennial ryegrass cultivars Trojan, Arrow and Bronsyn, as well as the *Bromus* cultivar Ceres Atom were the only cultivars that maintained the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate throughout the months from July to October. From October to March, however, the monthly growth rate of all these perennial ryegrass cultivars was lower ($P<0.05$) than the highest growth rate. The Tall Fescue cultivar Bariane was the only cultivar that maintained the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate from January to May.

The total seasonal and annual DM production of temperate perennial grass cultivars is shown in Table 9. There was no single cultivar that achieved the highest ($P<0.05$) seasonal DM during all seasons. The perennial ryegrass cultivars Trojan, Arrow and Bronsyn and Fescue cultivar Verdant had the highest ($P<0.05$) or similar ($P>0.05$) to the highest DM production during winter and spring, but their DM production was lower ($P<0.05$) than the highest producing cultivar during summer and autumn. The *Bromus* cultivar had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production during all seasons from winter to summer.

Table 4: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of Fescue cultivars during year 1

Species	Cultivar	July*	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
TF	Kora	1.75^{bc}	10.9^{bcde}	48.8^{bcd}	99.6^{ab}	79.8^{abc}	57.9^{abc}	64.9^{ab}	35.6^{cde}	45.1^{bcde}	48.0^{b}	26.0^{b}
TF	Tuscany	0.74^{bc}	6.44^{def}	40.2^{bcd}	111^{ab}	75.8^{abcd}	60.4^{abc}	70.7^{a}	49.8^{ab}	51.8^{ab}	52.3^{ab}	30.3^{ab}
TF	Barlite	0.80^{bc}	6.98^{def}	28.9^{de}	115^{ab}	73.9^{abcdef}	60.4^{abc}	74.3^{a}	43.0^{abcd}	49.5^{abc}	53.9^{ab}	27.3^{b}
TF	Verdant	5.27^{a}	25.5^{a}	71.1^{a}	102^{ab}	76.1^{abcd}	46.6^{bcde}	66.7^{a}	30.1^{e}	53.6^{ab}	46.2^{bcd}	26.0^{b}
TF	Jenna	2.02^{bc}	19.0^{ab}	57.5^{ab}	116^{ab}	81.1^{ab}	44.5^{cde}	74.8^{a}	34.2^{de}	52.8^{ab}	51.9^{ab}	30.9^{ab}
TF	KR6505	2.09^{bc}	18.0^{abc}	52.7^{abc}	107^{ab}	58.8^{defg}	72.6^{a}	62.4^{abc}	37.8^{bcde}	57.2^{ab}	60.0^{a}	31.0^{ab}
TF	GFM24	2.34^{b}	10.4^{bcdef}	43.4^{bcd}	102^{ab}	61.3^{cdef}	60.8^{abc}	40.9^{cdef}	30.3^{e}	35.8^{def}	48.0^{b}	32.6^{ab}
TF	Cochise	0.28^{c}	2.17^{ef}	16.2^{ef}	67.3^{cd}	39.7^{gh}	32.7^{de}	30.3^{f}	31.8^{de}	37.8^{cdef}	37.2^{cde}	33.7^{ab}
TF	Sidewinder	-	1.28^{f}	17.1^{ef}	48.7^{d}	35.6^{h}	26.3^{e}	33.8^{ef}	29.6^{e}	25.6^{fg}	36.6^{de}	15.2^{c}
TF	GFM29	0.97^{bc}	9.87^{bcdef}	41.7^{bcd}	102^{ab}	62.3^{bcdef}	58.4^{abc}	58.3^{abcd}	38.9^{bcde}	46.0^{abcd}	47.9^{a}	25.9^{b}
TF	Bronson forage	1.21^{bc}	8.39^{def}	45.4^{bcd}	95.6^{ab}	76.5^{abcd}	58.3^{abc}	70.4^{a}	41.2^{bcde}	49.5^{abc}	50.4^{ab}	30.9^{ab}
TF	Baroptima	1.35^{bc}	11.5^{bcde}	44.7^{bcd}	122^{a}	74.6^{abcde}	65.9^{ab}	60.4^{abc}	41.0^{bcde}	56.7^{ab}	54.8^{ab}	33.2^{ab}
TF	Bariane	1.26^{bc}	10.1^{bcdef}	46.7^{bcd}	116^{ab}	83.9^{a}	62.5^{abc}	66.3^{a}	53.4^{a}	58.6^{a}	55.9^{ab}	34.9^{ab}
TF	Barverde	1.41^{bc}	8.95^{cdef}	34.9^{cde}	90.0^{bc}	56.1^{efg}	45.9^{bcde}	55.8^{abcd}	32.5^{de}	44.6^{bcde}	54.3^{ab}	28.5^{ab}
TF	Boschoek	1.28^{bc}	9.67^{cdef}	45.1^{bcd}	105^{ab}	82.4^{a}	47.9^{bcd}	57.6^{abcd}	37.1^{cde}	51.1^{ab}	51.5^{ab}	28.1^{b}
TF	Advance	1.53^{bc}	13.4^{bcd}	56.7^{ab}	95.9^{ab}	72.0^{abcdef}	56.6^{abc}	60.3^{abc}	41.5^{abcde}	48.7^{abc}	47.2^{bc}	28.5^{ab}
MF	Laura	1.11^{bc}	8.53^{def}	43.2^{bcd}	91.1^{bc}	62.3^{cdef}	51.3^{bcd}	55.9^{abcd}	36.0^{cde}	32.9^{efg}	46.2^{bcd}	26.1^{b}
MF	Jamaica	1.47^{bc}	13.0^{bcd}	48.9^{bc}	98.9^{ab}	75.4^{abcde}	60.2^{abc}	54.1^{abcde}	34.2^{de}	38.1^{cdef}	53.7^{ab}	25.3^{bc}
CF	Rushmore	-	3.64^{ef}	8.18^{f}	50.6^{d}	54.7^{fgh}	52.7^{abcd}	37.8^{def}	33.4^{de}	23.0^{g}	34.0^{e}	28.7^{ab}
RF	Gibraltar	-	2.19^{ef}	7.22^{f}	51.9^{d}	73.1^{abcdef}	55.5^{abc}	43.2^{bcdef}	47.3^{abc}	37.3^{cdef}	46.5^{bcd}	38.8^{a}
LSD (0.05)		1.878	9.350	19.85	28.27	19.59	20.36	21.80	12.02	12.69	10.3	10.66

LSD (0.05) compares within month and over cultivars.

^{abc}Means with no common superscript differ significantly

* Growth rate from establishment to first harvest

TF: Tall Fescue; MF: Meadow Fescue; CF: Chewings Fescue; RF: Red Fescue

Table 5: Total seasonal and annual dry matter (kg DM ha^{-1}) production of Fescue cultivars

Species	**Cultivar**	**Winter**	**Spring**	**Summer**	**Autumn**	**Annual**
TF	Kora	490^{bcde}	6738^{abc}	4546^{abcd}	3309^{cde}	15082^{abcd}
TF	Tuscany	260^{def}	6697^{abc}	5175^{a}	3742^{abc}	15874^{abc}
TF	Barlite	281^{def}	6432^{abcd}	5080^{ab}	3627^{abc}	15419^{abc}
TF	Verdant	1277^{a}	7280^{ab}	4087^{bcd}	3507^{bcd}	16150^{ab}
TF	Jenna	749^{b}	7465^{a}	4356^{abcd}	3775^{abc}	16345^{ab}
TF	KR6505	727^{bc}	6353^{abcd}	4993^{ab}	4118^{a}	16190^{ab}
TF	GFM24	543^{bcd}	6063^{bcd}	3837^{cd}	3231^{cde}	13674^{cde}
TF	Cochise	70.9^{f}	3629^{f}	2723^{e}	3039de	9461^{f}
TF	Sidewinder	35.9^{f}	2998^{f}	2557^{e}	2123^{g}	7723^{f}
TF	GFM29	380^{bcdef}	6032^{bcd}	4475^{abcd}	3330^{cde}	14217^{bcd}
TF	Bronson forage	364^{bcdef}	6429^{abcd}	4863^{abc}	3642^{abc}	15297^{abcd}
TF	Baroptima	467^{bcde}	7083^{abc}	4821^{abc}	4030^{ab}	16401^{ab}
TF	Bariane	417^{bcdef}	7270^{ab}	5223^{a}	4163^{a}	17073^{a}
TF	Barverde	402^{bcdef}	5315de	3838^{cd}	3531^{bcd}	13086de
TF	Boschoek	407^{bcdef}	6880^{abc}	4081^{bcd}	3643^{abc}	15003^{abcd}
TF	Advance	539^{bcd}	6590^{abcd}	4543^{abcd}	3467^{cde}	15138^{abcd}
MF	Laura	357^{cdef}	5773^{cd}	4108^{bcd}	2909^{ef}	13148de
MF	Jamaica	522^{bcd}	6579^{abcd}	4284^{abcd}	3233^{cde}	14619^{bcd}
CF	Rushmore	102^{ef}	3353^{f}	3588de	2383^{fg}	9462^{f}
RF	Gibraltar	61.5f	4086^{ef}	4211^{abcd}	3415^{cde}	11774^{e}
		389.1	1367	1046	562.2	2254

LSD (0.05) compares within season and over cultivars.

^{abc}Means with no common superscript differ significantly

TF: Tall Fescue; MF: Meadow Fescue; CF: Chewings Fescue; RF: Red Fescue

Table 6: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of Cocksfoot cultivars during year 1

Cultivar	July*	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Athos	0.93^{ab}	11.6^{abc}	36.8^{c}	134^{a}	81.4^{b}	79.6^{ab}	58.4^{ab}	33.6^{abc}	47.2^{b}	54.0^{ab}	23.7^{ab}
Sparta	0.38^{b}	7.77^{bc}	36.5^{c}	93.3^{bc}	67.5^{b}	87.2^{a}	51.0^{ab}	33.1^{abc}	45.2^{b}	37.7^{cd}	17.4^{bc}
Niva	0.55^{b}	4.94^{c}	29.7^{c}	106^{abc}	77.4^{b}	83.1^{ab}	46.4^{b}	37.3^{abc}	40.4^{b}	37.3^{cd}	12.4^{c}
Cristobal	2.17^{a}	15.0^{ab}	66.6^{ab}	122^{ab}	84.9^{b}	90.1^{a}	55.6^{ab}	35.3^{abc}	44.4^{b}	47.6^{abc}	27.8^{ab}
Adremo	0.50^{b}	10.1^{abc}	47.2^{bc}	118^{ab}	110^{a}	77.5^{ab}	54.1^{ab}	34.4^{abc}	50.4^{ab}	46.8^{bcd}	30.9^{a}
Barvillo	0.56^{b}	9.61^{bc}	45.8^{c}	103^{abc}	81.6^{b}	84.3^{ab}	61.7^{a}	39.1^{ab}	45.1^{b}	47.0^{abc}	26.9^{ab}
Barexcel	0.48^{b}	8.61^{bc}	46.4^{bc}	104^{abc}	85.6^{b}	69.4^{b}	47.8^{ab}	30.9^{bc}	42.7^{b}	44.6^{bcd}	23.2^{ab}
Oxen	2.10^{a}	19.6^{a}	74.5^{a}	118^{ab}	72.8^{b}	68.0^{b}	58.8^{ab}	33.3^{abc}	45.9^{b}	42.0^{cd}	28.5^{a}
Hera	0.69^{b}	7.80^{bc}	47.1^{bc}	107^{abc}	81.3^{b}	69.9^{b}	44.8^{b}	28.9^{c}	47.4^{b}	39.0^{cd}	22.7^{abc}
Wana	0.49^{b}	6.49^{bc}	41.0^{c}	80.7^{c}	74.7^{b}	75.5^{ab}	54.6^{ab}	41.0^{a}	44.6^{b}	57.8^{a}	22.1^{abc}
Pizza	0.63^{b}	5.0^{c}	42.4^{c}	89.5^{bc}	83.5^{b}	72.9^{ab}	53.8^{ab}	30.3^{c}	59.1^{a}	35.9^{d}	20.8^{abc}
LSD (0.05)	1.251	9.520	20.44	37.03	20.23	17.24	14.67	8.675	11.47	10.92	10.49

LSD (0.05) compares within month and over cultivars.

^{abc}Means with no common superscript differ significantly

* Growth rate from establishment to first harvest

Table 7: Total seasonal and annual dry matter (kg DM ha^{-1}) production of Cocksfoot cultivars during year 1

Cultivar	Winter	Spring	Summer	Autumn	Annual
Athos	423^{abc}	7439^{abc}	4987^{ab}	3460^{a}	16309^{ab}
Sparta	259^{c}	5824^{d}	5005^{ab}	2796^{bc}	13884^{c}
Niva	197^{c}	6317^{cd}	4873^{ab}	2500^{c}	13888^{c}
Cristobal	651^{ab}	8015^{a}	5282^{a}	3332^{ab}	17280^{a}
Adremo	337^{bc}	8196^{a}	4825^{ab}	3572^{a}	16930^{a}
Barvillo	329^{bc}	6814^{abcd}	5374^{a}	3311^{ab}	15828^{abc}
Barexcel	285^{bc}	6937^{abcd}	4306^{b}	3071^{abc}	14599^{bc}
Oxen	773^{a}	7727^{ab}	4627^{ab}	3249^{ab}	16376^{ab}
Hera	293^{bc}	6937^{abcd}	4185^{b}	3048^{abc}	14463^{bc}
Wana	234^{c}	5833^{d}	4961^{ab}	3433^{a}	14462^{bc}
Pizza	207^{c}	6405^{bcd}	4560^{ab}	3250^{ab}	14422^{bc}
LSD (0.05)	386.0	1396	861.8	605.1	2312

LSD (0.05) compares within season and over cultivars.

^{abc}Means with no common superscript differ significantly

Table 8: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of temperate perennial grass cultivars

Species	Cultivar	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
TF	Kora	1.75^{b}	10.9^{efghij}	48.8^{defghijk}	99.6^{bcde}	80.0^{bcde}	57.9^{hijkl}	64.9^{abcde}	35.6^{defghij}	45.1^{cdefghijk}	48.0^{cdefgh}	26.0^{bcdefgh}
TF	Tuscany	0.74^{b}	6.4^{ghij}	40.2^{hijk}	111^{abcd}	75.8^{bcdef}	60.4^{ghijkl}	70.7^{abc}	49.8^{ab}	51.8^{abcdef}	52.3^{bcdef}	30.3^{abcdefg}
TF	Barlite	0.80^{b}	7.0^{ghij}	28.9^{klm}	115^{abcd}	73.9^{cdefgh}	60.4^{ghijkl}	74.3^{ab}	43.0^{bcd}	49.5^{abcdefgh}	53.9^{bcde}	27.3^{bcdefgh}
TF	Verdant	5.26^{a}	25.5^{abc}	71.1^{abc}	102^{bcde}	76.1^{bcdef}	46.6^{lm}	66.7^{abcd}	30.1^{ghij}	53.6^{abcd}	46.2^{defghij}	26.0^{bcdefgh}
TF	Jenna	2.02^{b}	19.0^{bcde}	57.5^{abcdefgh}	116^{abcd}	81.1^{bcd}	44.5^{lmn}	74.8^{a}	34.2^{defghij}	52.8^{abcde}	51.9^{bcdef}	30.9^{abcdef}
TF	KR6505	2.09^{b}	18.0^{cdef}	52.7^{cdefghi}	107^{abcde}	58.8^{fghi}	72.6^{cdefghi}	62.4^{abcdef}	37.8^{cdefghij}	57.2^{ab}	60.0^{ab}	31.0^{abcdef}
TF	GFM24	2.34^{b}	10.4^{defghij}	43.4^{hijk}	102^{bcde}	61.3^{efgh}	60.8^{fghijkl}	40.9^{ghijk}	30.3^{ghij}	35.8^{jklmn}	48.0^{cdefgh}	32.6^{abcde}
TF	Cochise	0.28^{b}	2.2^{ij}	16.2^{mn}	67.3^{fgh}	39.7^{ij}	32.7^{mn}	30.3^{k}	31.8^{fghij}	37.8^{hijklm}	37.2^{hijk}	33.7^{abc}
TF	Sidewinder	0.50^{b}	1.3^{j}	17.1^{lmn}	48.7^{h}	35.6^{j}	26.3^{n}	33.8^{jk}	29.6^{hij}	25.6^{no}	36.6^{ijk}	15.1^{ij}
TF	GFM29	0.97^{b}	9.9^{defghij}	41.7^{hijk}	102^{bcde}	62.3^{defgh}	58.4^{hijkl}	58.3^{abcdefgh}	38.9^{cdefghi}	46.1^{bcdefghijk}	47.9^{cdefgh}	25.9^{bcdefgh}
TF	Bronson forage	1.21^{b}	8.4^{fghij}	45.4^{ghijk}	95.6^{bcdef}	76.5^{bcdef}	58.3^{hijkl}	70.4^{abc}	41.2^{bcdef}	49.5^{abcdefgh}	50.4^{bcdefg}	30.9^{abcdef}
TF	Baroptima	1.35^{b}	11.5^{efghij}	44.7^{hijk}	122^{ab}	74.6^{bcdefg}	65.9^{efghijk}	60.4^{abcdefg}	41.0^{bcdef}	56.7^{abc}	54.8^{bcde}	33.2^{abcd}
TF	Bariane	1.26^{b}	10.1^{defghij}	46.1^{fghijk}	116^{abcd}	83.9^{bc}	62.5^{fghijkl}	66.3^{abcd}	53.4^{a}	58.6^{a}	55.8^{abcd}	34.9^{ab}
TF	Barverde	1.41^{b}	9.0^{efghij}	34.8^{ijklm}	90.0^{def}	56.1^{ghi}	45.9^{lm}	55.8^{abcdefgh}	32.5^{efghij}	44.6^{efghijkl}	54.3^{bcde}	28.5^{bcdefg}
TF	Boschoek	1.28^{b}	9.7^{defghij}	45.1^{ghijk}	105^{bcde}	82.4^{bc}	47.9^{klm}	57.6^{abcdefgh}	37.1^{defghij}	51.1^{abcdef}	51.5^{bcdefg}	28.1^{bcdefg}
TF	Advance	1.53^{b}	13.4^{defgh}	56.7^{bcdefgh}	95.9^{bcdef}	72.0^{bcdefgh}	56.6^{hijkl}	60.3^{abcdefg}	41.5^{bcdef}	48.7^{abcdefghi}	47.2^{cdefghi}	28.5^{bcdefg}
MF	Laura	1.11^{b}	8.5^{fghij}	43.2^{hijk}	91.1^{cdef}	62.3^{defgh}	51.2^{ijklm}	55.9^{abcdefgh}	36.0^{defghij}	32.9^{lmno}	46.2^{defghij}	26.1^{bcdefgh}
MF	Jamaica	1.47^{b}	13.0^{defgh}	48.9^{defghij}	98.9^{bcde}	75.4^{bcdefg}	60.2^{ghijkl}	54.1^{bcdefghij}	34.2^{defghij}	38.1^{ghijklm}	53.7^{bcde}	25.3^{bcdefgh}
CF	Rushmore	-	3.6^{hij}	7.2^{n}	50.6^{h}	54.7^{hij}	52.7^{jkl}	37.8^{hijk}	29.5^{hij}	23.0^{o}	34.0^{k}	28.7^{bcdefg}
RF	Gibraltar	-	2.2^{ij}	8.2^{n}	51.9^{gh}	73.1^{bcdefgh}	55.5^{ijkl}	43.2^{fghijk}	47.3^{abc}	37.3^{ijklmn}	46.5^{defghij}	38.8^{a}
CoF	Athos	0.93^{b}	11.6^{efghij}	36.8^{ijkl}	134^{a}	81.4^{bcd}	79.6^{bcdef}	58.4^{abcdefg}	33.6^{defghij}	45.7^{bcdefghijk}	54.0^{bcde}	23.7^{defghi}
CoF	Sparta	0.38^{b}	7.0^{fghij}	36.5^{ijkl}	93.3^{bcdef}	64.5^{cdefgh}	87.2^{bcd}	51.0^{cdefghij}	33.1^{defghij}	45.2^{bcdefghijk}	37.7^{hijk}	12.4^{j}
CoF	Niva	0.68^{b}	4.9^{ghij}	29.7^{jklm}	106^{abcde}	77.4^{bcdef}	83.1^{bcde}	46.4^{defghijk}	37.3^{cdefghij}	40.4^{fghijklm}	37.3^{hijk}	17.4^{hij}
CoF	Cristobal	2.17^{b}	15.0^{defg}	66.6^{abcde}	122^{ab}	84.9^{bc}	90.1^{bc}	55.6^{abcdefgh}	35.3^{defghij}	44.4^{defghijklm}	47.6^{cdefgh}	27.8^{bcdefg}
CoF	Adremo	0.50^{b}	10.1^{defghij}	47.2^{efghijk}	118^{abcd}	110^{a}	77.5^{cdefg}	54.1^{bcdefghij}	34.4^{defghij}	50.4^{abcdef}	46.8^{defghij}	30.9^{abcdef}
CoF	Barvillo	0.56^{b}	9.6^{defghij}	45.8^{fghijk}	103^{bcde}	81.6^{bcd}	84.3^{bcde}	61.7^{abcdef}	39.1^{cdefgh}	45.1^{cdefghijk}	47.0^{cdefghi}	26.9^{bcdefgh}
CoF	Barexcel	0.48^{b}	8.6^{fghij}	46.4^{fghijk}	104^{bcde}	83.6^{bc}	69.4^{defghij}	47.8^{defghijk}	30.9^{ghij}	42.7^{defghijklm}	44.6^{efghijk}	23.2^{efghi}
CoF	Oxen	2.10^{b}	19.6^{bcd}	74.5^{ab}	118^{abcd}	72.8^{bcdefgh}	68.0^{efghij}	58.9^{abcdefg}	33.3^{defghij}	45.9^{bcdefghijk}	42.0^{fghijk}	28.5^{bcdefg}
CoF	Hera	0.69^{b}	7.8^{fghij}	47.1^{efghijk}	107^{abcde}	81.3^{bcd}	68.9^{defghij}	44.8^{efghijk}	28.9^{j}	47.4^{abcdefghij}	39.0^{hijk}	22.7^{efghi}
CoF	Wana	0.49^{b}	6.5^{ghij}	41.0^{hijk}	80.7^{efg}	74.7^{bcdefg}	75.5^{cdefgh}	54.6^{abcdefghi}	41.0^{bcdef}	44.6^{defghijkl}	57.8^{abc}	22.1^{fghij}
CoF	Pizza	0.63^{b}	5.0^{ghij}	42.4^{hijk}	89.5^{def}	83.5^{bc}	72.9^{cdefghi}	53.8^{bcdefghij}	30.3^{ghij}	59.1^{a}	35.9^{jk}	20.8^{ghij}
PR	Remington	1.81^{b}	15.1^{cdefg}	52.6^{cdefghi}	106^{abcde}	74.1^{bcdefg}	45.6^{lm}	34.4^{ijk}	33.8^{defghij}	32.4^{mno}	40.8^{ghijk}	29.1^{abcdefg}
PR	Bealy	4.97^{a}	19.3^{bcde}	65.6^{abcdef}	120^{abc}	78.0^{bcdef}	62.3^{fghijkl}	57.6^{abcdefgh}	41.9^{bcde}	44.7^{cdefghijkl}	53.9^{bcde}	28.7^{bcdefg}
PR	Trojan	5.48^{a}	31.2^{a}	74.0^{ab}	121^{ab}	79.7^{bcde}	56.9^{hijkl}	49.7^{defghijk}	29.0^{ij}	37.8^{hijklm}	40.8^{ghijk}	30.0^{abcdefg}
PR	Arrow	5.42^{a}	30.5^{a}	68.5^{abcd}	110^{abcd}	88.5^{b}	67.9^{efghij}	51.0^{cdefghij}	33.2^{defghij}	34.1^{klmno}	66.3^{a}	26.3^{bcdefgh}
PR	Bronsyn	5.44^{a}	28.6^{ab}	64.9^{abcdefg}	106^{abcde}	81.1^{bcd}	48.8^{klm}	49.3^{defghijk}	36.9^{defghij}	41.5^{efghijklm}	44.7^{efghijk}	25.4^{bcdefgh}
BC	Ceres Atom	5.17^{a}	32.0^{a}	77.2^{a}	121^{ab}	87.8^{b}	110^{a}	65.3^{abcde}	40.0^{bcdefg}	53.1^{abcde}	39.1^{hijk}	29.2^{abcdefg}
BP	GBP02	1.80^{b}	12.2^{defghi}	68.0^{abcd}	116^{abcd}	90.6^{ab}	96.5^{ab}	72.6^{ab}	41.9^{bcde}	50.1^{abcdefg}	42.1^{fghijk}	24.2^{cdefghi}
LSD (0.05)		2.34	10.36	19.83	28.96	19.35	18.88	20.58	9.98	12.05	10.91	9.940

LSD (0.05) compares within month and over cultivars. ^{abc}Means with no common superscript differ significantly

TF: Tall Fescue; MF: Meadow Fescue; CF: Chewings Fescue; RF: Red Fescue; CoF: Cocksfoot; PR: Perennial ryegrass; BC: *Bromus catharticus*; BP: *Bromus parodii*

* Growth rate from establishment to first harvest

Table 9: Total seasonal and annual dry matter production (kg DM ha^{-1}) of temperate perennial grass cultivars

Species	Cultivar	Winter	Spring	Summer	Autumn	Annual
TF	Kora	490^{cdefgh}	6738^{defghij}	4546^{cdefghijk}	3309^{defghij}	15082^{cdefgh}
TF	Tuscany	260^{efgh}	6697^{efghij}	5175^{bcde}	3742^{abcd}	15874^{bcdef}
TF	Barlite	281^{defgh}	6432	5080^{cdef}	3627^{abcdef}	15419^{cdefg}
TF	Verdant	1277^{a}	7280^{abcdefghi}	4087^{ghijkl}	3507^{cdefg}	16150^{bcde}
TF	Jenna	749^{bcd}	7464^{abcdefgh}	4356^{defghijk}	3775^{abcd}	16345^{bcde}
TF	KR6505	727^{bcde}	6353^{hijk}	4993^{cdefg}	4118^{ab}	16190^{bcde}
TF	GFM24	543^{bcdefg}	6063^{ijk}	3837^{jkl}	3231^{defghij}	13674^{fghi}
TF	Cochise	70.9^{gh}	3629^{m}	2723^{mn}	3039^{ghijk}	9461^{j}
TF	Sidewinder	35.9^{h}	2998^{m}	2557^{n}	2132^{m}	7723^{j}
TF	GFM29	380^{cdefgh}	6032^{ijk}	4475^{cdefghijk}	3330^{defghij}	14217^{efgh}
TF	Bronson forage	364^{cdefgh}	6429^{fghijk}	4863^{cdefgh}	3642^{abcde}	15297^{cdefgh}
TF	Baroptima	467^{cdefgh}	7083^{abcdefghij}	4821^{cdefghi}	4030^{abc}	16401^{bcde}
TF	Bariane	417^{cdefgh}	7270^{abcdefghi}	5223^{bcde}	4164^{a}	17073^{bcd}
TF	Barverde	402^{cdefgh}	5315^{kl}	3838^{jkl}	3531^{cdefg}	13086^{hi}
TF	Boschoek	407^{cdefgh}	6880^{cdefghij}	4081^{ghijkl}	3634^{abcde}	15003^{defgh}
TF	Advance	539^{cdefg}	6590^{efghijk}	4543^{cdefghijk}	3467^{cdefgh}	15138^{cdefgh}
MF	Laura	357^{cdefgh}	5773^{jk}	4108^{ghijkl}	2910^{hijkl}	13148^{hi}
MF	Jamaica	522^{cdefg}	6579^{efghijk}	4284^{efghijk}	3234^{defghij}	14619^{efgh}
CF	Rushmore	102^{gh}	3353^{m}	3588^{klm}	2383^{lm}	9426^{j}
RF	Gibraltar	61.5^{gh}	4086^{lm}	4211^{ghijkl}	3415^{defghi}	11774^{i}
CoF	Athos	423^{cdefgh}	7439^{abcdefgh}	4987^{cdefg}	3460^{cdefgh}	16309^{bcde}
CoF	Sparta	259^{efgh}	5824^{jk}	5005^{cdefg}	2796^{jkl}	13884^{fghi}
CoF	Niva	197^{fgh}	6317^{hijk}	4873^{cdefgh}	2500^{klm}	13888^{fghi}
CoF	Cristobal	651^{bcdef}	8015^{abcd}	5282^{bcd}	3332^{defghij}	17280^{abc}
CoF	Adremo	337^{cdefgh}	8196^{ab}	4825^{cdefghi}	3572^{bcdefg}	16930^{bcd}
CoF	Barvillo	329^{cdefgh}	6814^{cdefghij}	5374^{abc}	3311^{defghij}	15828^{bcdef}
CoF	Barexcel	285^{defgh}	6937^{bcdefghij}	4306^{efghijk}	3071^{efghijk}	14599^{efgh}
CoF	Oxen	773^{bc}	7727^{abcdef}	4627^{cdefghi}	3249^{defghij}	16376^{bcde}
CoF	Hera	293^{cdefgh}	6937^{bcdefghij}	4185^{fghijkl}	3048^{fghijk}	14463^{efgh}
CoF	Wana	234^{fgh}	5833^{jk}	4961^{cdefg}	3434^{defgh}	14462^{efgh}
CoF	Pizza	207^{fgh}	6405^{ghijk}	4560^{cdefghij}	3250^{defghij}	14422^{efgh}
PR	Remington	617^{bcdef}	6833^{cdefghij}	3288^{lmn}	2845^{ijkl}	13583^{ghi}
PR	Bealy	1071^{ab}	6581^{efghijk}	4659^{cdefghij}	3529^{cdefg}	15839^{bcdef}
PR	Trojan	1459^{a}	7885^{abcde}	3916^{hijkl}	3025^{ghijk}	16284^{bcde}
PR	Arrow	1435^{a}	7711^{abcdefg}	4412^{defghijk}	3476^{cdefgh}	17034^{bcd}
PR	Bronsyn	1382^{a}	7407^{abcdefgh}	3877$_{ijkl}$	3100^{efghij}	15766^{bcdefg}
BP	Ceres Atom	1449^{a}	8356^{a}	6289^{a}	3404^{defghi}	19497^{a}
BC	GBP02	534^{cdefg}	8083^{abc}	6126^{ab}	3247^{defghij}	17990^{ab}
LSD (0.05)		483.9	1310	962.1	580.0	2241

LSD (0.05) compares within season and over cultivars.

^{abc}Means with no common superscript differ significantly

TF: Tall Fescue; MF: Meadow Fescue; CF: Chewings Fescue; RF: Red Fescue; CoF: Cocksfoot; PR: Perennial ryegrass; BC: *Bromus catharticus*; BP: *Bromus parodii*

The highest (P<0.05) annual DM production was for the *Bromus* cultivar Ceres Atom, with similar (P>0.05) production obtained by the *Bromus* cultivar GBP02 and the Cocksfoot cultivar Cristobal. Various Fescue and Cocksfoot cultivars had a similar (P>0.05) total annual DM production to the highest yielding perennial ryegrass cultivar.

Conclusions

1. *Bromus* as a species, and the two *Bromus* cultivars, Ceres Atom and GBP02 were highly productive during year 1. The persistence and ability of *Bromus* cultivars to remain productive in following years still needs to be evaluated.
2. Aside from the Fescue cultivar Verdant, all Cocksfoot and Fescue cultivars were slow to establish and had lower productions than highest producing perennial ryegrass cultivars during winter.
3. From spring onwards various Cocksfoot and Fescue cultivars had similar production to the highest producing perennial ryegrass cultivars.
4. The production potential of perennial temperate grass species/cultivars during year two and three after establishment will have to be evaluated to make informed decisions on which to utilise within a system.

Message to the farmer

Alternative temperate perennial grasses to perennial ryegrass are available for utilisation in pastures.

Although some species, such as Cocksfoot and Tall Fescue, are slower to establish than perennial ryegrass, they can be as productive as ryegrass from spring onwards.

The decision on which cultivar/species to include in a fodder-flow program should be based on the seasonal dry matter production of the species and the role it can play in the fodder-flow program.

References

ARC. 2005. Instructions for the completion of National Ryegrass Evaluation Programme.

Beyers CP. 1973. Bemesting van aangeplante wiedings. *Winterreën Spesiale Uitgawe* 5, 54-59.

Botha PR. 2002. Die gebruik van vogspanningmeters vir besproeiingskedulering by weidings. *Weidingskursus Inligtingsbundel 2002.* Suid Kaap Landbou-ontwikkelinsentrum, Departement Landbou Wes-Kaap. pp 141-149.

Botha PR. 2003. Die produksie potensiaal van oorgesaaide kikoejoeweiding in die gematigde kusgebied van die Suidkaap. PhD thesis, University of the Free State, South Africa.

Botha PR, Gerber HS, Zulu B. 2008. Die seisoenale droëmateriaalproduksie van Kropaargras, Swenkgras en verskillende meer-en eenjarige raaigrasspesies. *Proceedings of Outeniqua Research Farm Information Day 2008*. Western Cape Department of Agriculture, South Africa.

Callow MN, Lowe KF, Bowdler TM, Lowe SA, Gobius NR. 2003. Dry matter yield, forage quality and persistence of tall fescue (*Festuca arundinacea*) cultivars compares with perennial ryegrass (*Lolium perenne*) in a subtropical environment. *Australian Journal of Experimental Agriculture*. 43:1093-1099.

Nie ZN, Miller S, Moore GA, Hackney BF, Boschma SP, Reed KFM, Mitchell M, Albertsen TO, Clark S, Craig AD, Kearney G, Li GD, Dear BS. 2008. Field evaluation of perennial grasses and herbs in southern Australia 2. Persistence, root characteristics and summer activity. *Australian Journal of Experimental Agriculture*. 48:424-435.

Ott RL. (1998) An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051)

Reed KFM. 1996. Improving the adaptation of perennial ryegrass, tall fescue, phalaris and cocksfoot for Australia. *New Zealand Journal of Agricultural Research*. 39:457-464.

Soil Classification Workgroup. 1991. Soil Classification, a Taxonomic system for South Africa. Memoirs on the Natural Agricultural Resources of South Africa. Nr 15. Department of Agricultural Development, Pretoria.

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.

THE EVALUATION OF ANNUAL LEGUME CULTIVARS FOR THE SOUTHERN CAPE

J van der Colf[1], PR Botha[1] and MM Lombard[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

A large amount of cool season annual forage legume cultivars are available in South Africa. Such forage legumes are valued for their high forage quality (Wasserman, 1981) and their ability to fix nitrogen through their association with Rhizobium bacteria in root nodules (Strijdom *et al.* 1980). Annual cool-season legumes provide forage from autumn to spring, except if winter temperatures are too low, impeding growth (Donaldson 2001). Forage legumes produce a higher quality pasture than pure grass stands and is therefore sown in a mixture with grass (Bartholomew, 2005). The legume component contributes greatly to nutritional value, palatability, digestibility and intake of such grass-legume pastures (Wasserman 1981, Botha 2008).

Annual legumes refer to plants having a lifespan of one year or less (Bartholomew 2005). The forage legumes included in this trial are Arrowleaf clover (*Trifolium vesiculosum*), Balansa clover (*T. michelianum* Savi.), Berseem clover (*T. alexandrinum* L.), Biserrula (*Biserrula pelecinus*), Barrel medic (*Medicago trancatula*), Burr clover (*M. polymorpha*), Sub clover (*T. subterraneun*), Persian clover (*T. resupinatum*), Pink serradella (*O. sativus*) and Grazing vetch (*Vicia dasycarpa*). The aim of this study was to evaluate the production potential of 22 annual cool season forage legume cultivars.

Materials and methods

The study was carried out on the Outeniqua Research farm near George (Altitude 201 m, 33° 58' 38" S and 22° 25' 16" E, rainfall 728 mm year^{-1}) in the Western Cape of South Africa on an Witfontein soil form (Soil Classification Workgroup 1991). The study area was under permanent overhead sprinkler irrigation, with irrigation scheduling undertaken by means of a tensiometer. Irrigation commenced at a tensiometer reading of -25 kPa and was terminated at a reading of -10 kPa (Botha 2002).

Soil samples were taken prior to establishment to a depth of 150mm and analysed for Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S, and C levels. Fertiliser was applied according to the soil analysis to raise soil P level to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and pH (KCl) to 5.5 (Beyers 1973).

A total of 22 cultivars were evaluated in the form of a randomized block design, with three replicates per cultivar (total of 54 plots). The scientific name, common name, cultivar name and seeding rate of the annual legumes that were evaluated are given in Table 1.

Table 1: The scientific name, common name, cultivar name and seeding rate (kg ha^{-1}) of annual legumes that were evaluated during the study.

	Scientific name	Common name	Cultivar name	Seeding rate
1	*Trifolium alexandrinum*	Berseem	Calipso	10
2	*Trifolium alexandrinum*	Berseem	Elite II	10
3	*Trifolium vesiculosum*	Arrowleaf	Zulu	15
4	*Trifolium vesiculosum*	Arrowleaf	Cefalo	15
5	*Trifolium michelianum*	Balansa	Viper	4
6	*Trifolium michelianum*	Balansa	Taipan	4
7	*Trifolium subterranean*	Subterranean	Losa	15
8	*Trifolium subterranean*	Subterranean	Dalkeith	15
9	*Trifolium subterranean*	Subterranean	Woogenellup	15
10	*Trifolium subterranean*	Subterranean	Campeda	15
11	*Trifolium resipunatum*	Persian	Morbulk	10
12	*Trifolium resipunatum*	Persian	Laser	10
13	*Trifolium resipunatum*	Persian	Maral	10
14	*Vicia dasaycarpa*	Vetch	Max	35
15	*Vicia dasaycarpa*	Vetch	Capello	35
16	*Medicago truncutula*	Barrel medic	Paraggio	15
17	*Medicago truncutula*	Barrel medic	Parabinga	15
18	*Medicago polymorpha*	Burr Medic	Jaguar	15
19	*Medicago polymorpha*	Burr Medic	Santiago	15
20	*Medicago polymorpha*	Burr Medic	Scimitar	15
21	*Ornithopus sativus*	Pink serradella	Emena	25
22	*Ornithopus sativus*	Pink serradella	Margurita	25

The trial was established on the 18th of April 2011. The trial area was sprayed with herbicide, tilled with a disk harrow and kongskilde and rolled with a light landroller to create a firm seedbed and eradicate any weeds. The various cultivars/species were planted according to commercially recommended seeding rates and adapted for germination percentages. Plots were 2.1 m x 6 m per treatment (12.6 m^2), with 14 rows that were 15 cm apart. All seed was inoculated with species specific *Rhizobium* a maximum of 2 hours before planting and kept in a cool place until it could be planted. Seed was also treated with pesticide and fungicide prior to establishment. Immediately after establishment, each plot was raked lightly to cover seeds and maintain inoculant activity.

Plots were harvested every 28 days using quadrats to determine growth rate (kg DM ha^{-1} day^{-1}) and dry matter (DM) production (kg DM ha^{-1}). Three quadrats of 0.25 m^2 were randomly placed per plot and cut to a height of 50 mm. The samples were pooled and weighed. A grab sample of approximately 500g green material was taken from the pooled sample, weighed, dried at 60⁰C for 72 hours and weighed to determine DM content. After sampling plots were cut to a uniform height of 50 mm above ground level using a Honda Lawnmower. Plots were only fertilised when deficiency symptoms become apparent or if deficiencies were identified in the soil analysis. Weed control was exercised mainly by mechanical means.

A Student least significant difference (LSD) at 5 % significance level was performed to compare the treatment means (Ott 1998). The STATS module of SAS version 9.2 (2008) was used to analyze the data.

Results and Discussion

The mean monthly growth rate of annual legumes is shown in Table 2.

Table 2: Mean monthly growth rate (kg DM ha^{-1} day^{-1}) of annual ryegrass cultivars during 2011

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

LSD (0.05) compares within month and over cultivars.

^{abc}Means with no common superscript differ significantly

* Growth rate from establishment to first harvest

The growth rate of species varied over months, with different cultivars achieving the highest growth rate during different months. The following cultivars could be harvested four times, whereas the rest could only be harvested three times:

- Both the Berseem cultivars (Calipso and Elite II)
- Both Balansa cultivars (Viper and Taipan)
- Both Serradella cultivars (Emena and Margurita)
- All three Persian clover cultivars (Morbulk, Laser and Maral)
- The Arrowleaf cultivar Zulu

- The Subterranean cultivars Woogenellup and Campeda

All medic and Vetch cultivars were only harvested three times.

The total seasonal and annual dry matter (DM) production of the annual legumes evaluated is given in Table 3. The annual legumes were only productive during winter and spring. During winter the Barrel medic cultivar Parragio and Serradella cultivar Emena had similar (P>0.05) DM production to the Berseem cultivar Calipso, Barrel medic cultivar Parabinga and Serradella cultivar Margurita, but higher (P<0.05) than the rest. The spring DM production of the Serradella cultivar Emena was similar (P>0.05) to that of the other Serradella cultivar, Margurita, and the Berseem clover cultivar Elite II, but higher than the rest. The highest (P<0.05) annual dry matter production was for the Serradella cultivar Emena, with only the other Serradella cultivar, Margurita having a similar (P>0.05) production.

Table 3: Total seasonal and annual dry matter production (kg DM ha^{-1}) of annual legume cultivars during 2011

Species	Cultivar	Winter	Spring	Annual
Berseem	Calipso	2065^{abc}	2385^{cde}	4450^{bcd}
Berseem	Elite II	1376^{ef}	3468^{ab}	4844^{bc}
Arrowleaf	Zulu	468^{hi}	1961^{defgh}	2429^{ghi}
Arrowleaf	Cefalo	250^{i}	1194^{ghijk}	1444^{ijk}
Balansa	Viper	612^{ghi}	1677^{defghi}	2289^{hij}
Balansa	Taipan	497^{hi}	1849^{defghi}	2346^{hij}
Subterranean	Losa	1523^{de}	1979^{defgh}	3502^{defg}
Subterranean	Dalkeith	984^{fg}	351^{kl}	1335^{jk}
Subterranean	Woogenellup	1465^{de}	2651^{bcd}	4116^{cde}
Subterranean	Campeda	829^{gh}	1845^{defghi}	2674^{fgh}
Persian	Morbulk	600^{ghi}	2232^{def}	2832^{fgh}
Persian	Laser	499^{hi}	1914^{defghi}	2413^{ghij}
Persian	Maral	555^{ghi}	2185^{defg}	2740^{fgh}
Vetch	Max	1646^{cde}	1614^{efghi}	3260^{efgh}
Vetch	Capello	1654^{cde}	948^{ijkl}	2602^{fgh}
Barrel medic	Paraggio	2428^{a}	1967^{defgh}	4395^{cd}
Barrel medic	Parabinga	2211^{ab}	1365^{fghij}	3576^{def}
Burr Medic	Jaguar	1916^{bcd}	1106^{hijkl}	3022^{fgh}
Burr Medic	Santiago	383^{hi}	139^{l}	476^{k}
Burr Medic	Scimitar	405^{hi}	413^{jkl}	818^{k}
Serradella	Emena	2418^{a}	3943^{a}	6362^{a}
Serradella	Margurita	2228^{ab}	3291^{abc}	5520^{ab}
LSD (0.05)		457.7	998.5	1093

LSD (0.05) compares within month and over cultivars.

^{abc}Means with no common superscript differ significantly

The highest producing cultivars (in terms of annual DM production) for each species are listed below. The highest producing cultivar is listed first and any similar (P>0.05) producing cultivars after:

- Berseem clover: Both cultivars had similar (P>0.05) DM production.
- Arrowleaf clover: Both cultivars had similar (P>0.05) DM production.

- Balansa cover: Both cultivars had similar (P>0.05) DM production.
- Subterranean clover: Woogenellup, with similar (P>0.05) from Losa.
- Persian clover: Three cultivars had similar (P>0.05) DM production
- Vetch: Both cultivars had similar (P>0.05) DM production.
- Medics: Barrel medic cultivars Parragio and Parabinga.
- Serradella: Both cultivars had similar (P>0.05) DM production.

Conclusions

1. Temperate annual legumes that are established during autumn will produce a maximum of four harvests/grazings, providing forage primarily from midwinter to early spring.
2. The Serradella cultivars Emena and Margurita were the most productive during this study for this region.

Message to the Farmer

Annual legumes can be established to provide high quality forage during midwinter and early spring.

The selection of the annual legume species/cultivar to establish should be based on the seasonal DM production of the species/cultivar, the specific fodder-flow shortage it is required to fill, the local climatic conditions and the prevalent pests and diseases.

References

Bartholomew PE 2005. Adaptation of pasture species. KZN agriculture and environmental affairs. Available online at http://agriculture.kzntl.gov.za/portal/AgricPublications/ProductionGuidelines/PasturesinKwaZuluNatal/AdaptationofPasturesSpecies/tabid/300/Default.aspx [Visited on 8 December 2008].

Beyers CP. 1973. Bemesting van aangeplante wiedings. *Winterreën Spesiale Uitgawe* 5, 54-59.

Botha PR. 2002. Die gebruik van vogspanningmeters vir besproeiingskedulering by weidings. *Weidingskursus Inligtingsbundel 2002*. Suid Kaap Landbou-ontwikkelinsentrum, Departement Landbou Wes-Kaap. pp 141-149.

Botha PR 2008. Faktore wat die volhoubaarheid vna klawer in 'n gras-klawerweiding beïnvloed. Outeniqua Navorsingsplaas Weidingskursusbundel 2008. Bl 86 – 90.

Donaldson CH 2001. A practical guide to planted pastures. Chapter 1, pp 2, 3; Chapter 5, p 49.

Ott RL. (1998) An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051)

Soil Classification Workgroup. 1991. Soil Classification, a Taxonomic system for South Africa. Memoirs on the Natural Agricultural Resources of South Africa. Nr 15.

Strijdom BW, Wasserman VD 1980. A.3 Die Belangrikheid van Peulgewasse in die landbou. Boerdery in Suid-Afrika. Peulgewasse A.3/1980

Wasserman VD 1981. C.6 Voorsiening van Weiding van hoë Gehalte Deur Middel van Gras-Klawermengsels. Boerdery in Suid-Afrika. Peulgewasse C.6/1981

THE PRODUCTION POTENTIAL OF ITALIAN AND WESTERWOLDS RYEGRASSES PLANTED AT DIFFERENT PLANTING DATES

PR Botha[1] & LB Zulu[1]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

Introduction

The seasonal variation in growth and nutritional value of perennial pastures restrict animal production. The fodder flow program for dairy and beef cattle production units in the coastal region of the Southern Cape of South Africa consist mainly of combinations of perennial pastures such as lucerne (*Medicago sativa*), Kikuyu (*Pennisetum clandestinum*), perennial ryegrass (*Lolium multiflorum*) and clover species (*Trifolium repens* en *T. pratense*). The growth rates of these crops differ during spring, summer and autumn, but reach a mutual low during winter (Van Heerden *et al.* 1989). In an effort to overcome the problem of pasture shortages during winter, seasonal variation in growth and pasture quality, farmers in the Southern cape plant annual ryegrass (*Lolium multiflorum spp*.) in pure stands, in mixtures with other annual grasses or as crops 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.

Procedures

The study was carried out between 2009 and 2011 on the Outeniqua Research Farm near George (altitude 201 m, 33° 58' 38'' S and 22° 25' 16'' E, rainfall 729 mm year^{-1}) in the Western Cape of South Africa. The area has a temperate climate, with mean minimum and maximum air temperatures varying between 7 ^{0}C -15 ^{0}C and 18 ^{0}C - 25 ^{0}C, respectively. The study was a small-plot trial carried out on an Estcourt soil type (Soil Classification Workgroup 1991) under irrigation. The grasses were sown in 150 mm rows at a seeding rate of 20 kg ha^{-1} for the diploid and 25 kg ha^{-1} for the tatraploid cultivars. Plot size for each cultivar was 10.5 m^{2}. Irrigation was applied by means of a permanent overhead sprinkler system in one or two applications per week, at rates of 10-15 mm, based on tensiometer readings. Irrigation commenced at a tensiometer reading of -25 kPa and was terminated at a reading of -10 kPa. Annual ryegrass (*L. multiflorum*) varieties nl. Italicum (Italian ryegrass) and Westerwoldicum (Westerwolds ryegrass) were evaluated. The data of four Italian and four Westerwolds ryegrass cultivars planted in separate plots were pooled and the production rate and total production calculated. The varieties, ploid and cultivars combined and used as treatments, are given in Table 1.

Prior to planting, fertiliser was applied according to the soil analysis to raise soil phosphorous (P) level to 35 mg kg^{-1} (citric acid), potassium (K) level to 80 mg kg^{-1} and pH (KCl) to 5.5. Nitrogen (N) was applied to the grass and grass-legume pastures at a rate of 50 kg N ha^{-1} $month^{-1}$.

All the treatments were planted on 24 consecutive months from May 2009 until April 2011 in a well prepared seedbed. The dry matter (DM) production was estimated by cutting the treatments by means of a sickle bar mover set to a height of 50 mm at an interval of 28-35 days, when the ryegrasses had reached the three leave stage or when overshadowing of the growing points of grasses had started to occur (Fulkerson & Donaghy 2001). Samples were dried at 60°C for 72 hours to a constant mass and weighed to determine DM content (%) and dry matter (DM) production.

The trial was a randomised complete block design with 184 treatment combinations randomly replicated in two blocks. The treatment design was a factorial with two factors namely planting dates and cultivars. An appropriate analysis of variance (ANOVA) was performed, using SAS/STAT software, Version 9.2 (SAS, 2008). The Shapiro-Wilk test (Shapiro & Wilk 1965) was performed to test normality of residuals and Student's t-LSD (least significant difference) (Ott 1993) was calculated at a 5% significance level to compare treatment means.

The two treatments evaluated during the trial according to annual ryegrass variety, ploidy and cultivar combinations are given in Table 1.

Table 1: The two treatments evaluated during the trial according to annual ryegrass (*L. multiflorum*) variety, ploidy and cultivar combinations.

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

Results and discussion

Figures 1a to 12a show the annual combined monthly growth rate (kg DM ha^{-1} day^{-1}) over two years of Italian and Westerwolds ryegrass cultivars planted at different planting dates. The growth rate (kg DM ha^{-1} day^{-1}) and number of harvests differ ($P<0.05$) over planting dates. The growth rates of Italian and Westerwolds ryegrasses planted during January until July were similar ($P>0.05$) in the beginning of the growth cycle but as the growth season prolongs the growth rate of Westerwolds ryegrass decreased and was lower ($P<0.05$) than that of Italian ryegrass during the latter part of the growth cycle. The growth rate of Italian ryegrass was higher than Westerwolds ryegrass during peak production when planted in

August, September and October but did not differ (P>0.05) when planted during November and December.

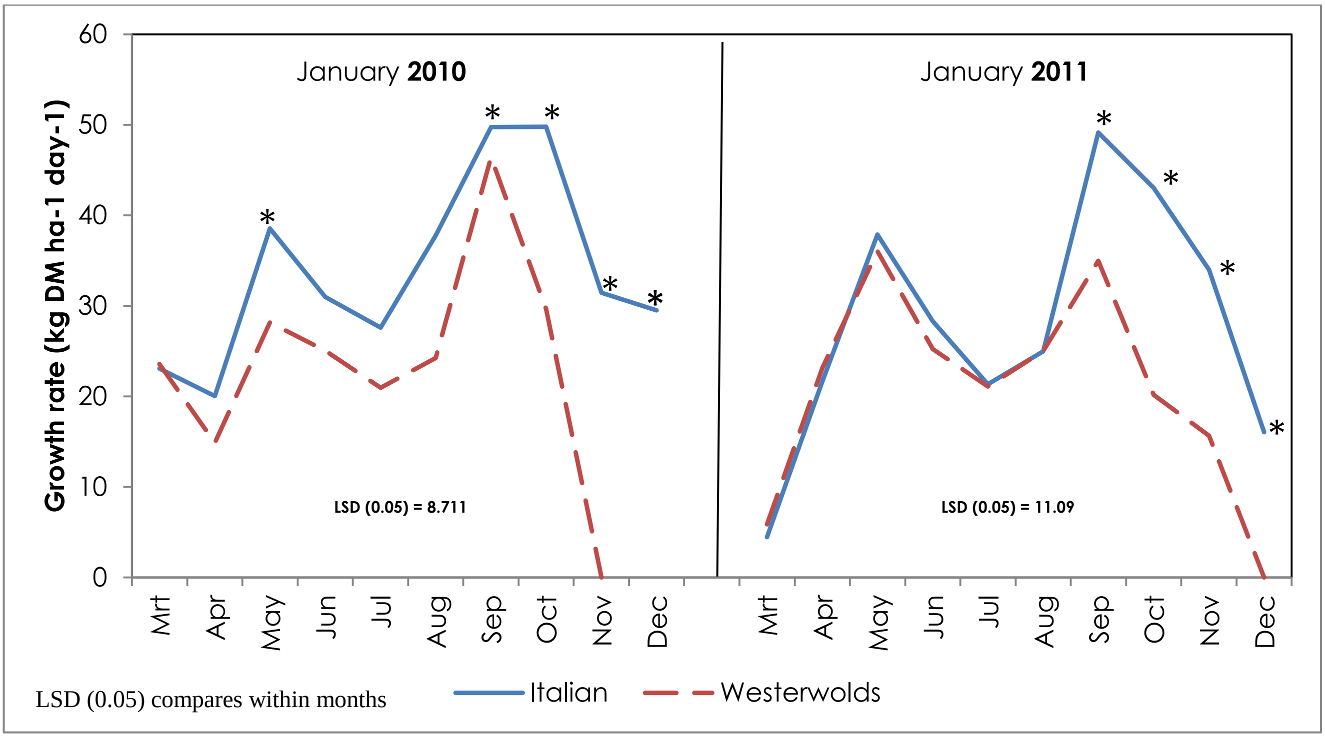


Figure 1a. Monthly growth rate of Italian and Westerwolds ryegrass planted during January 2010 and January 2011

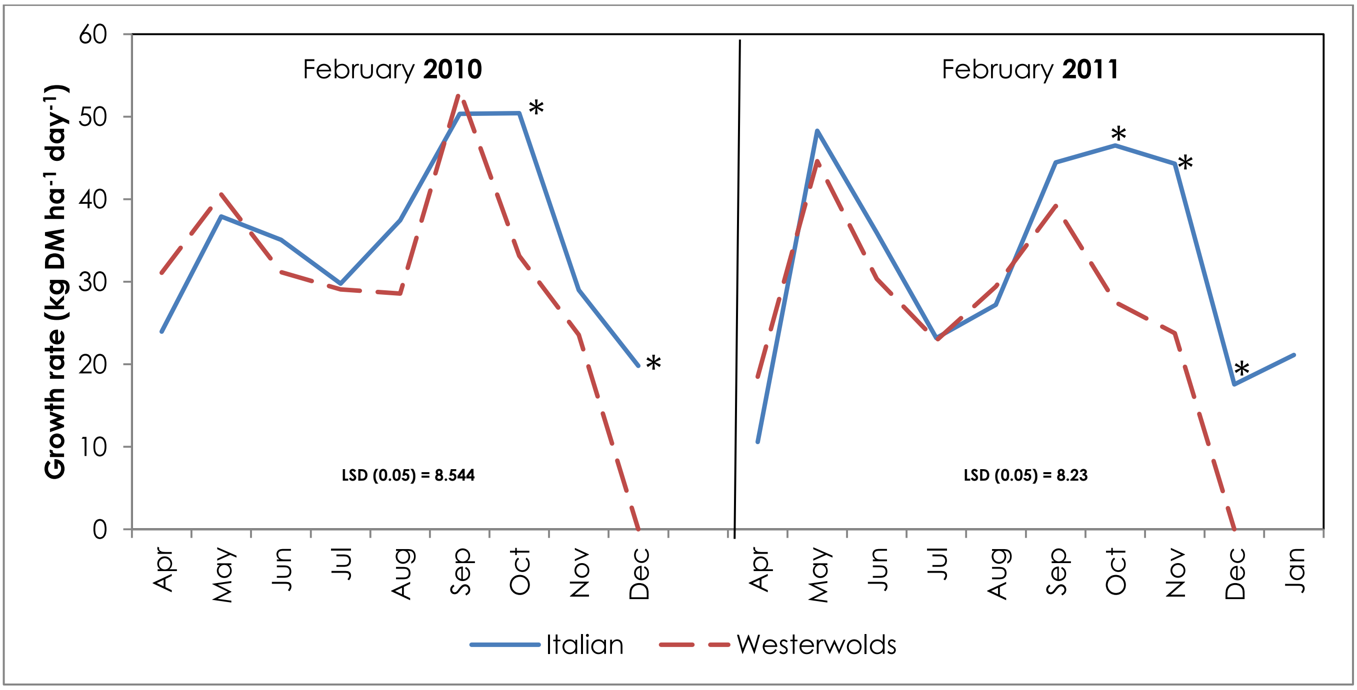


Figure 2a. Monthly growth rate of Italian and Westerwolds ryegrass planted during February 2010 and February 2011

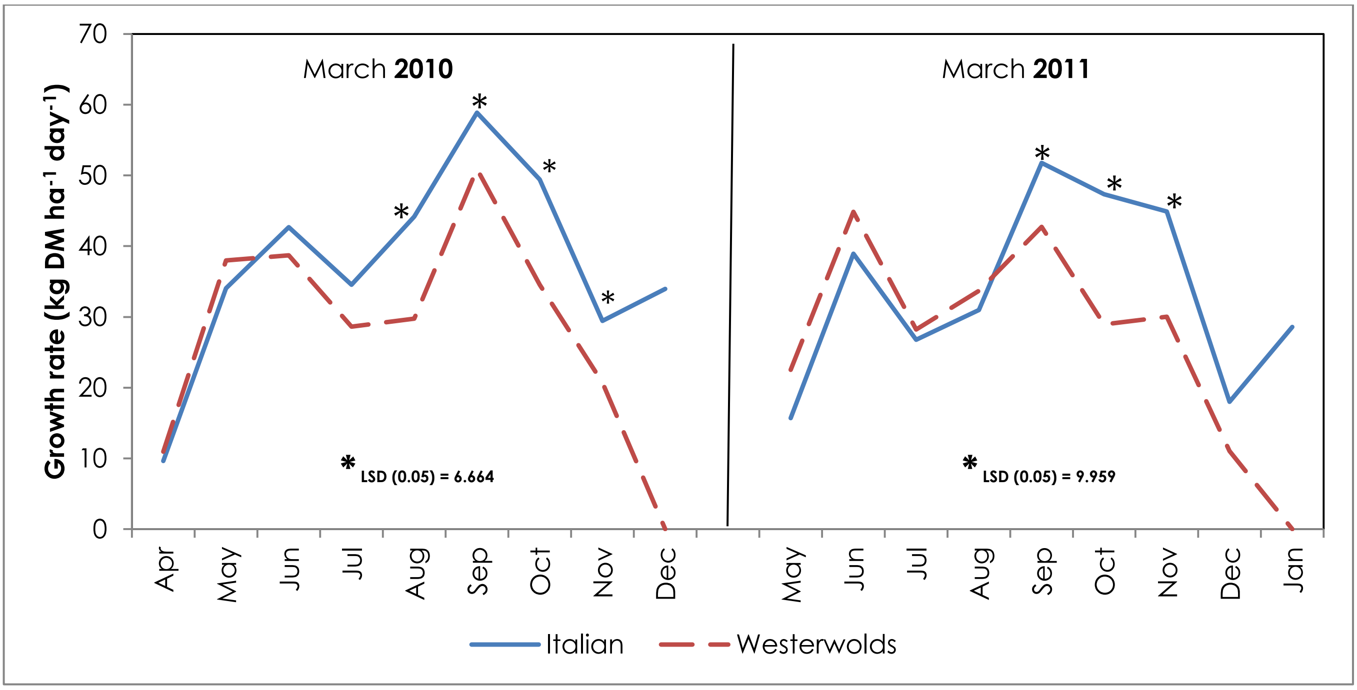


Figure 3a. Monthly growth rate of Italian and Westerwolds ryegrass planted during March 2010 and March 2011

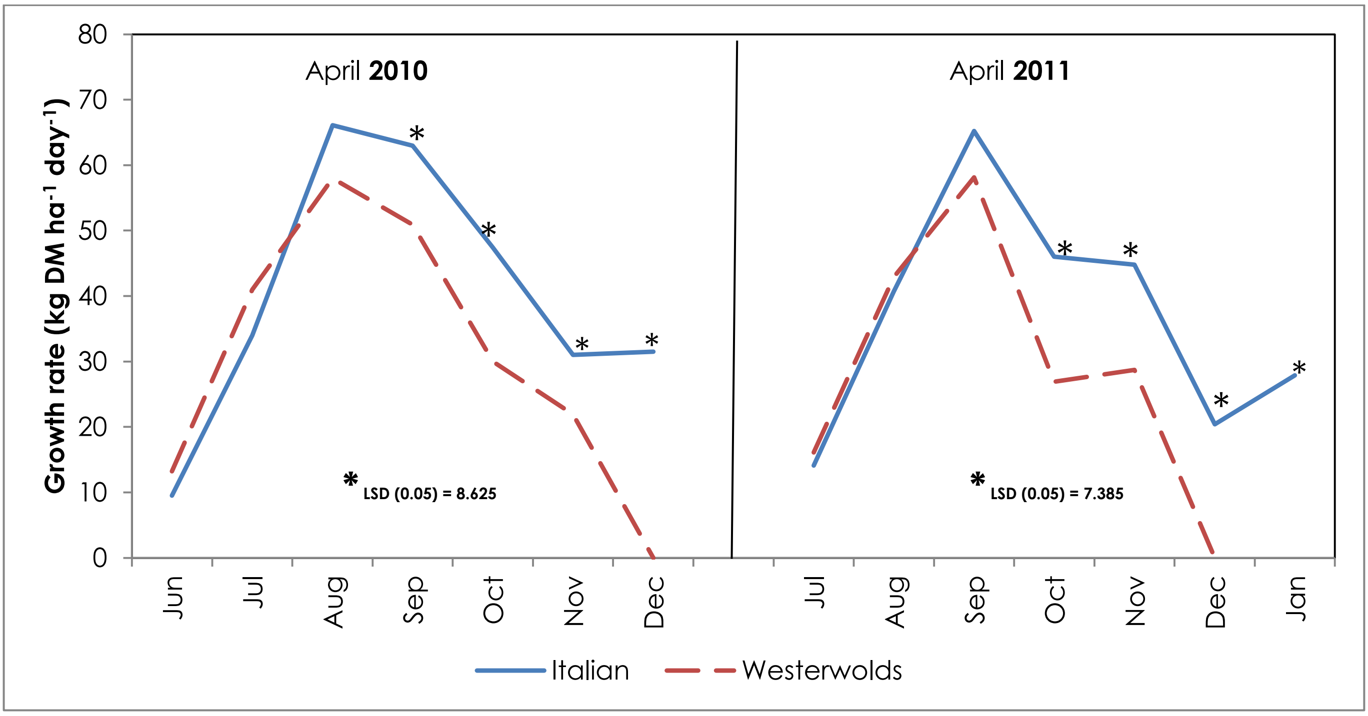


Figure 4a. Monthly growth rate of Italian and Westerwolds ryegrass planted during April 2010 and April 2011

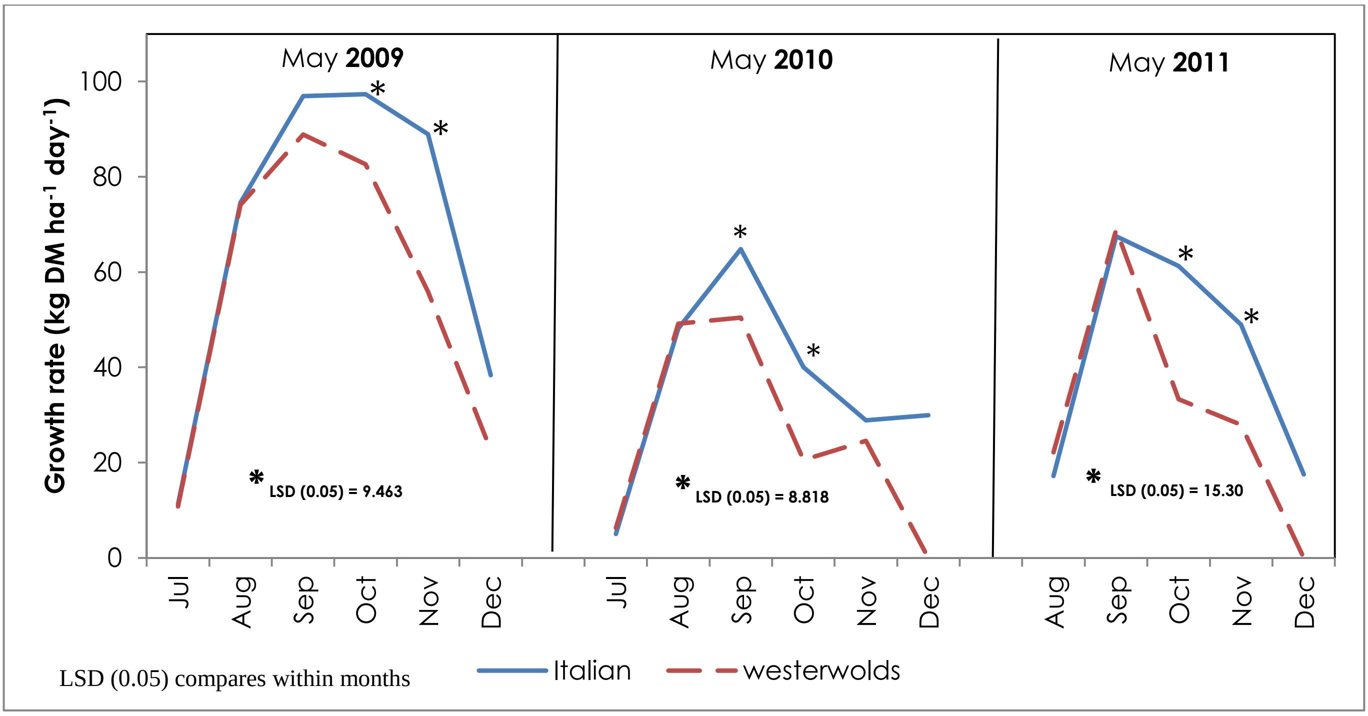


Figure 5a. Monthly growth rate of Italian and Westerwolds ryegrass planted during May 2009, May 2010 and May 2011

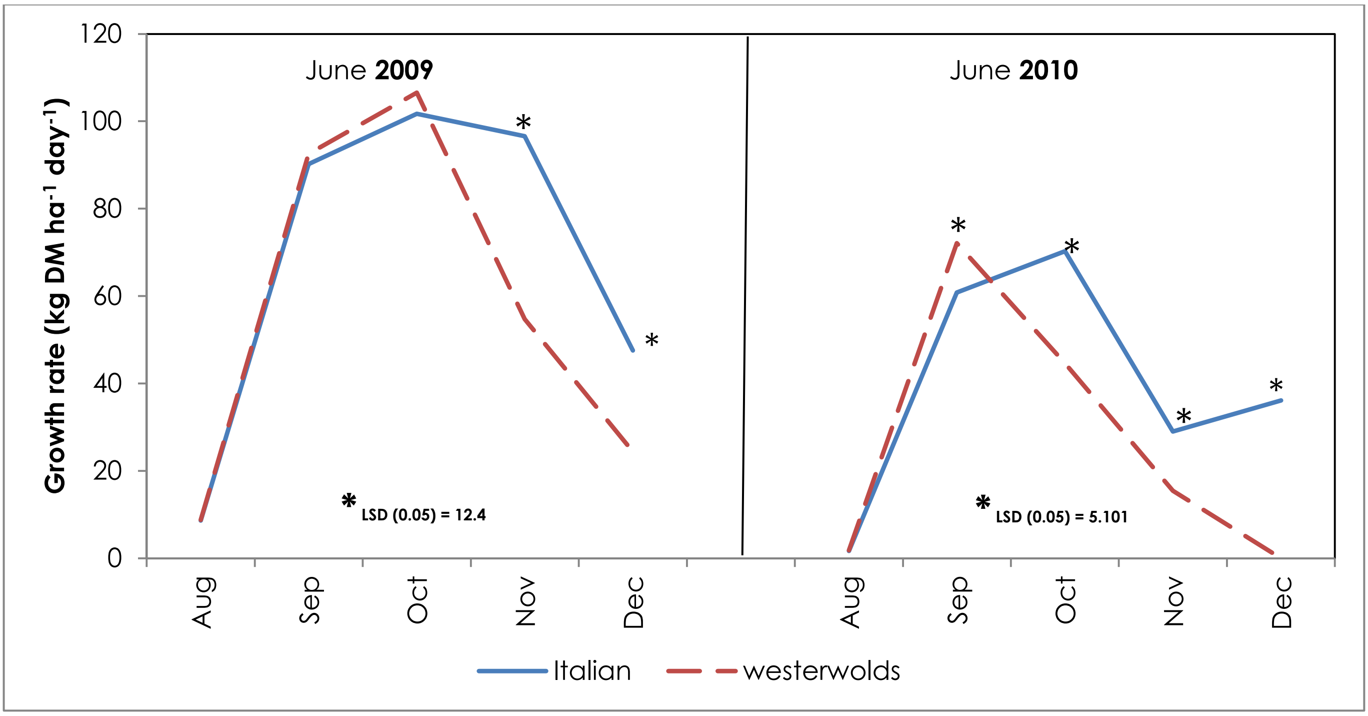


Figure 6a. Monthly growth rate of Italian and Westerwolds ryegrass planted during June 2009 and June 2010

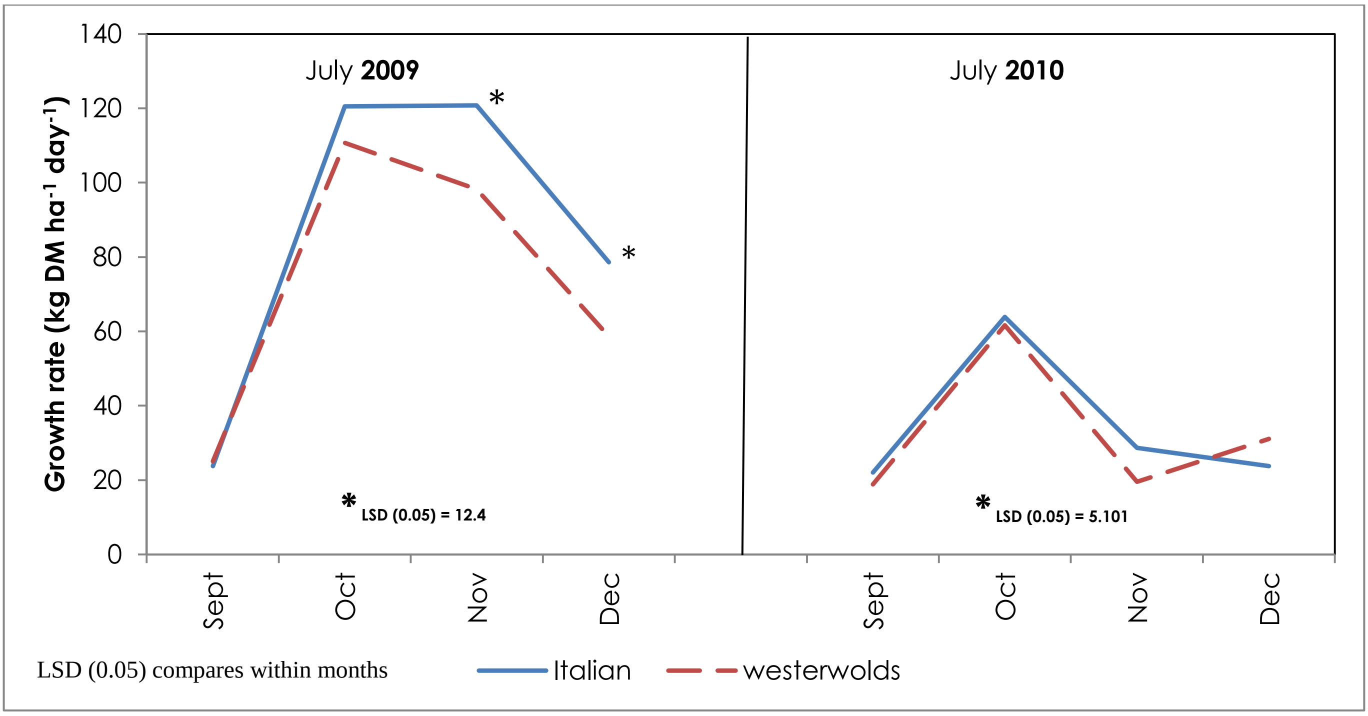


Figure 7a. Monthly growth rate of Italian and Westerwolds ryegrass planted during July 2009 and July 2010

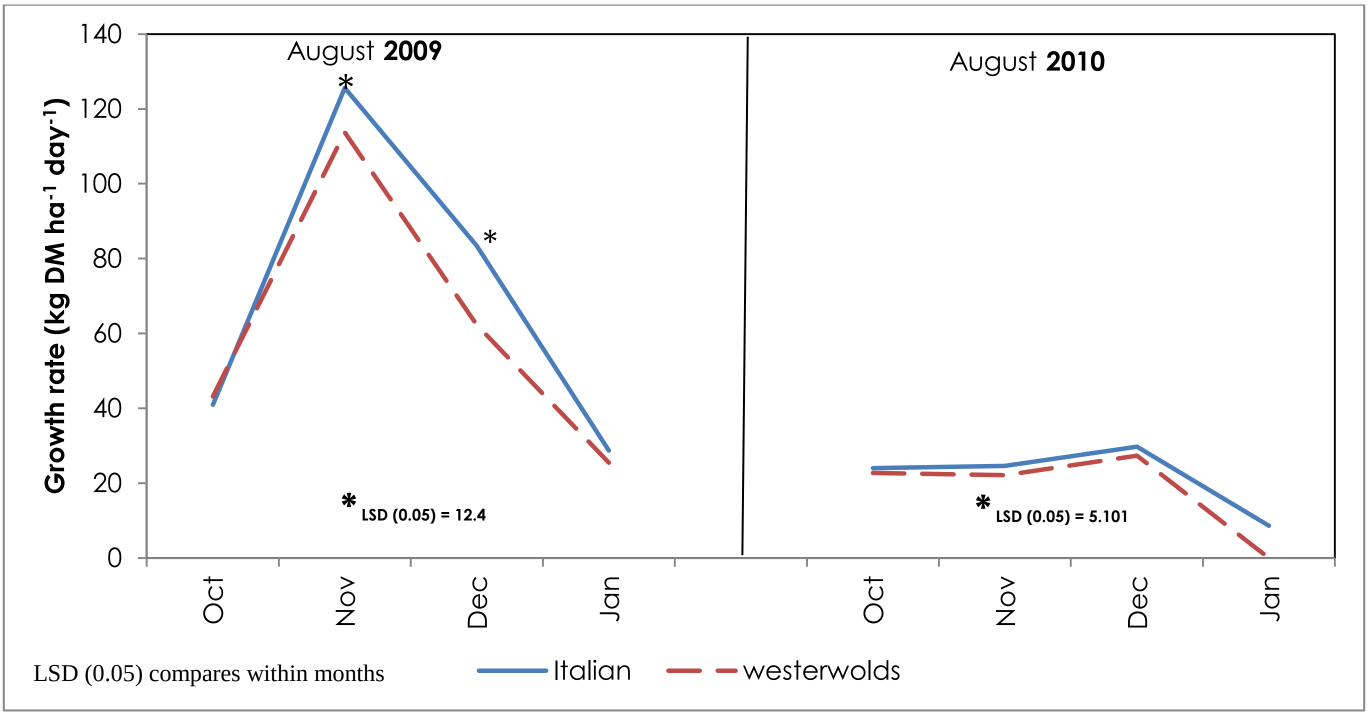


Figure 8a. Monthly growth rate of Italian and Westerwolds ryegrass planted during August 2009 and August 2010

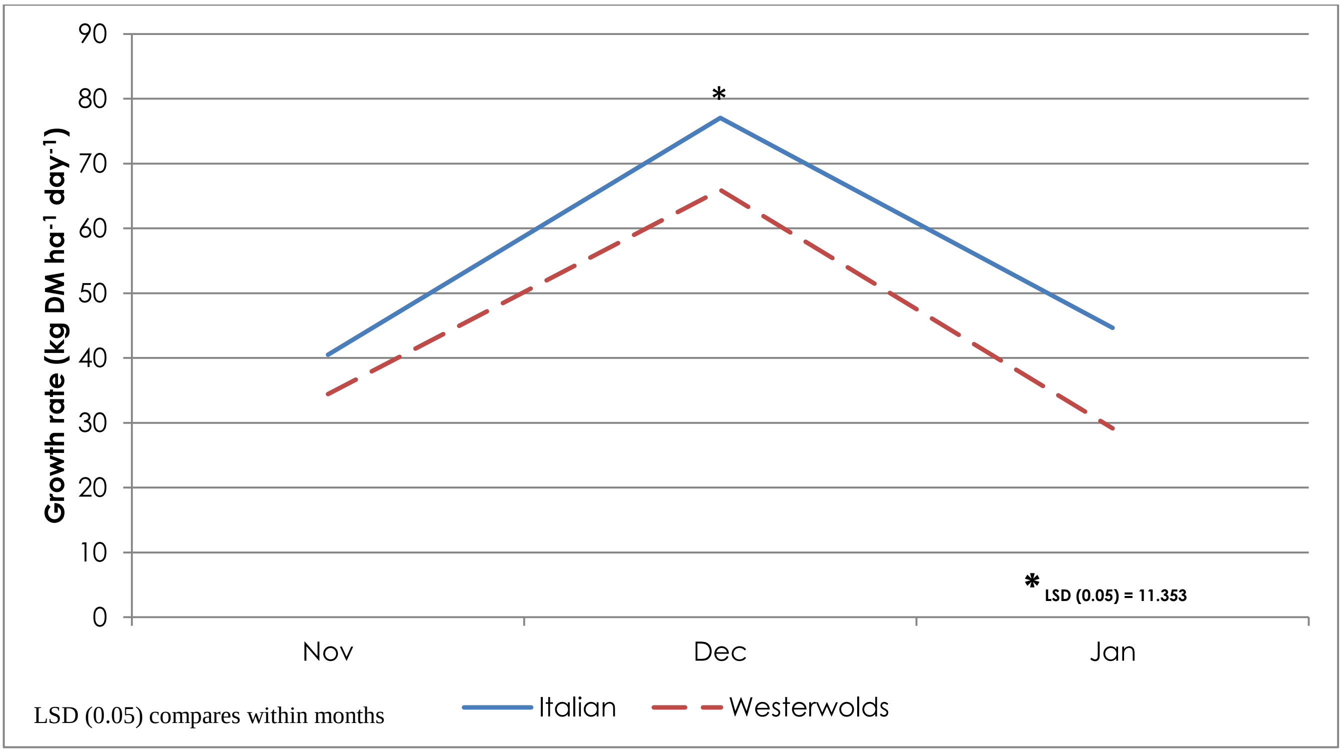


Figure 9a. Monthly growth rate of Italian and Westerwolds ryegrass planted during September 2009

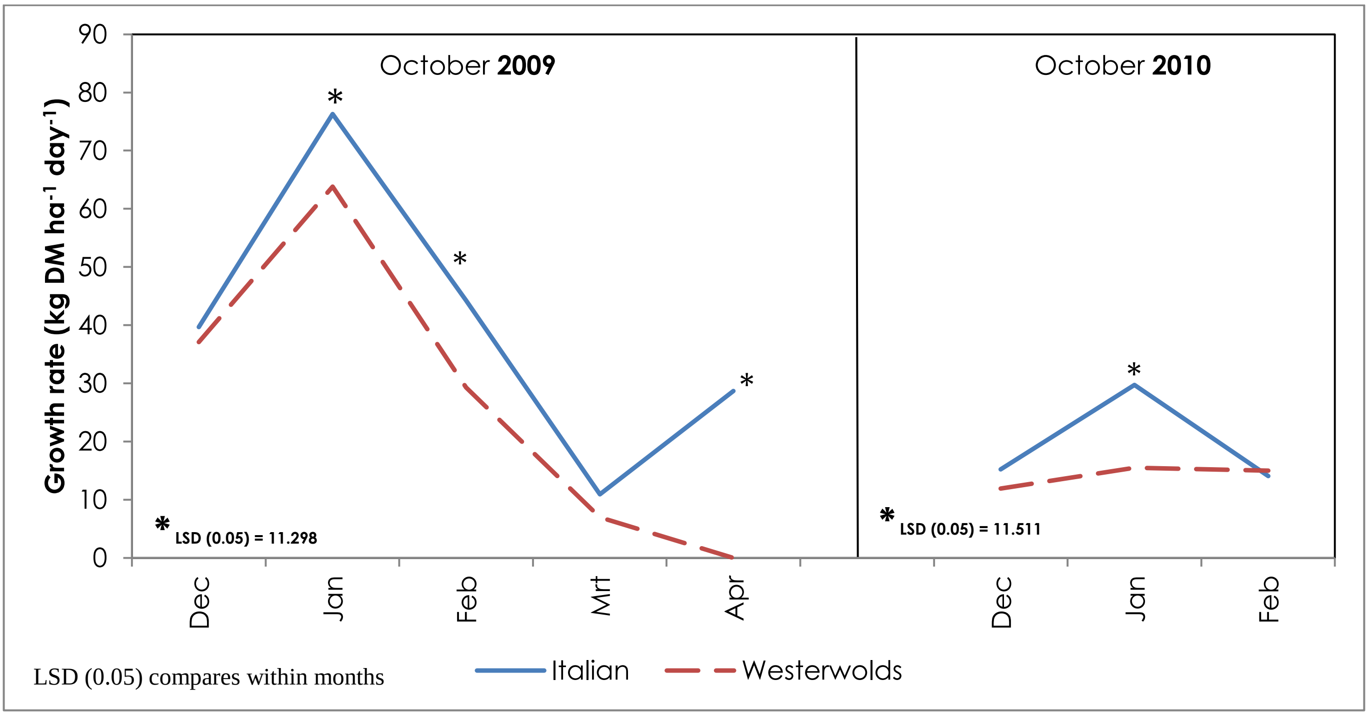


Figure 10a. Monthly growth rate of Italian and Westerwolds ryegrass planted during ctober 2009 and October 2010

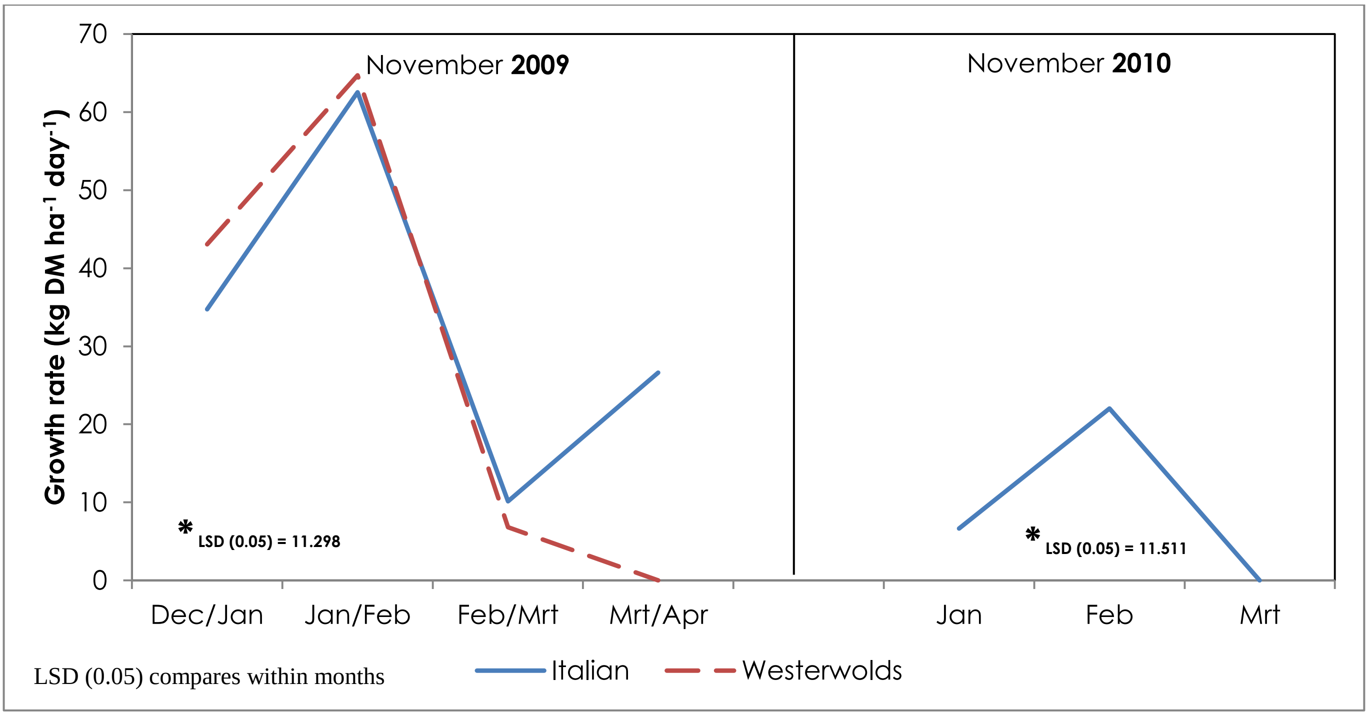


Figure 11a. Monthly growth rate of Italian and Westerwolds ryegrass planted during November 2009 and November 2010

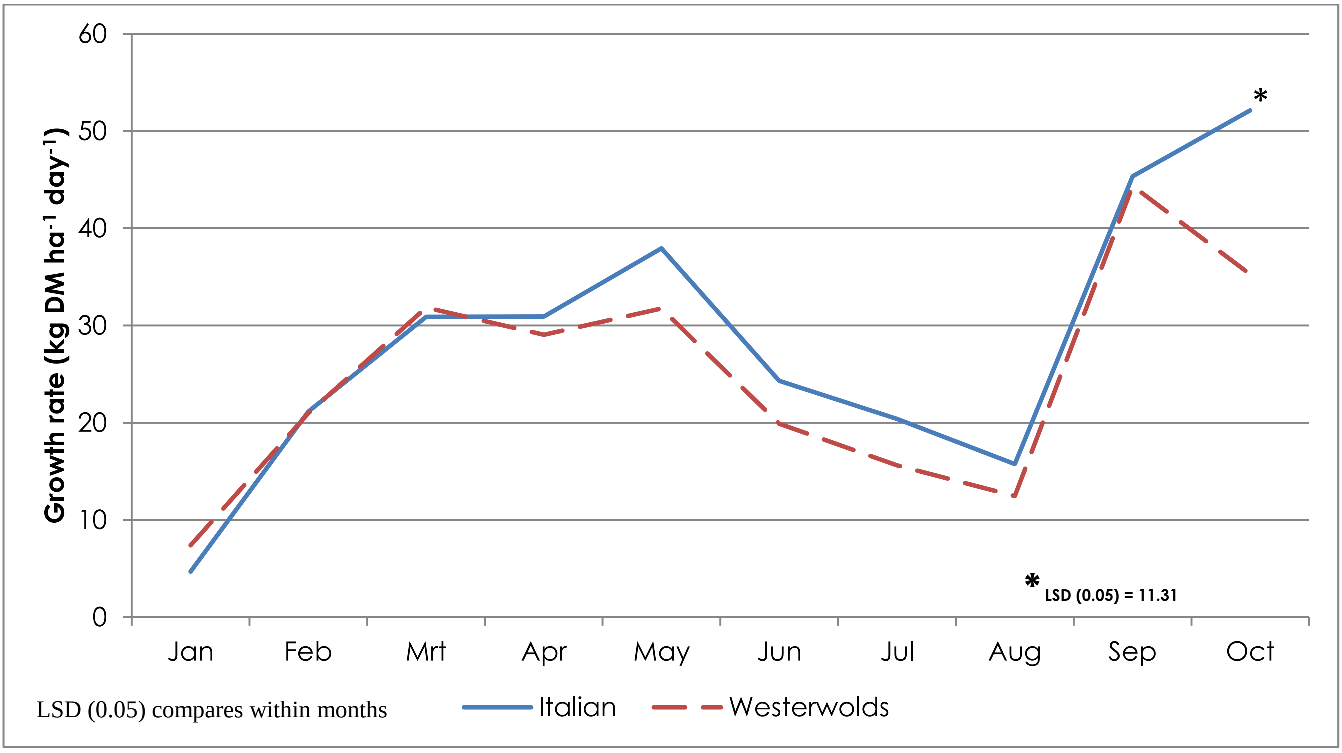


Figure 12a. Monthly growth rate of Italian and Westerwolds ryegrass planted during December 2009

The data also indicated that the seasonal growth rate of Italian and Westerwolds ryegrass over years can vary or be similar depending on the planting date. The growth rate of Italian and Westerwolds ryegrass over years was similar when planted during February, March and April but varies when planted from May until November. This was mainly due to climatic factors like temperature and rainfall and the effect it have on weed invasion from August until November. It can be expected that high rainfall during spring and early summer will have a pronounced effect on the invasion of weeds like Yellow nutsedge (*Cyperus esculentus*) (Afr. Uientjies) and Crab finger grass (*Digitaria sanguinalis*) (Afr. Kruisgras) than during warmer and drier seasons.

Figures 1b to 12b show the average (two years) monthly growth rate (kg DM ha^{-1} day^{-1}) of Italian and Westerwolds ryegrasses planted at different planting dates over the trial period.

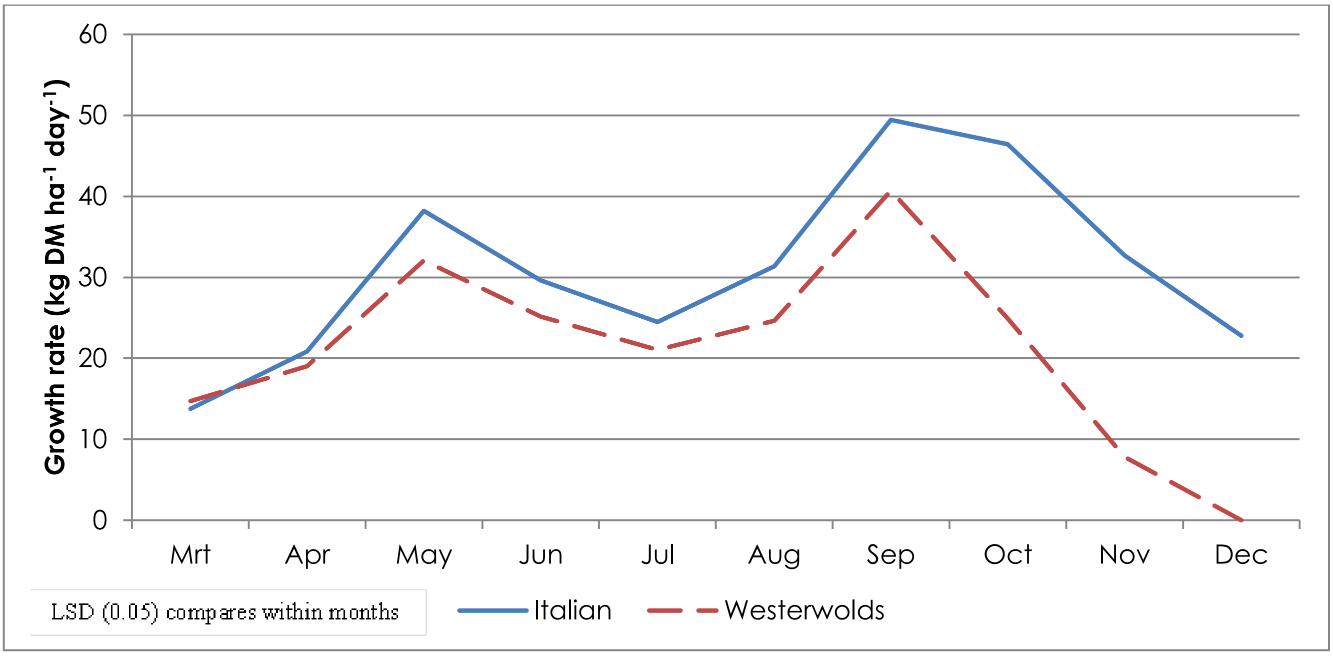


Figure 1b. Mean monthly growth rate of ryegrass planted during January

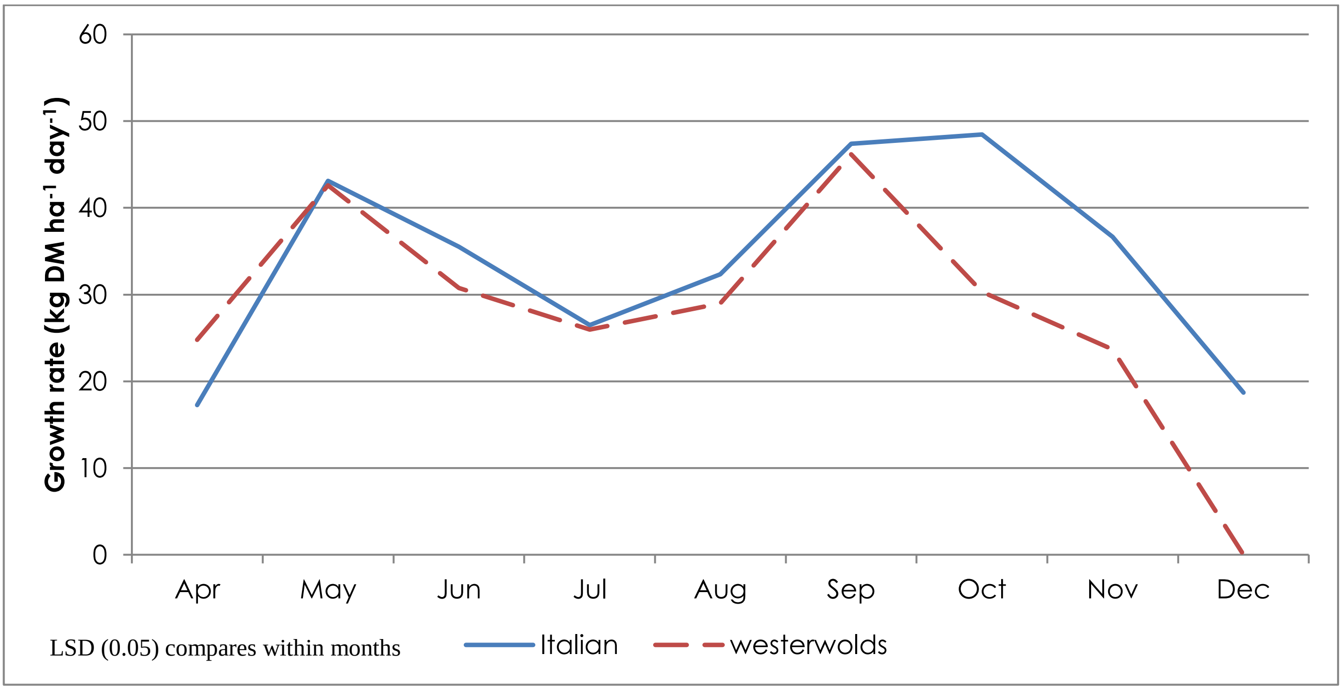


Figure 2b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during February

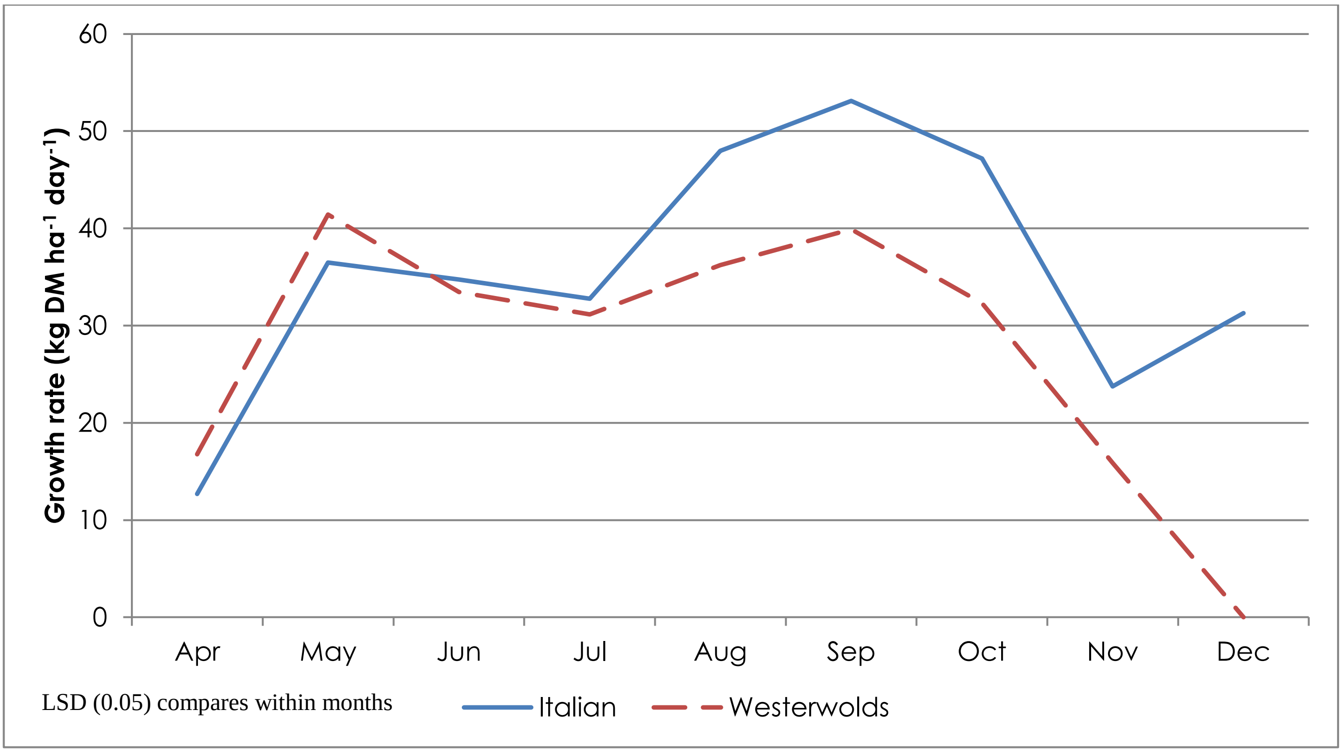


Figure 3b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during March

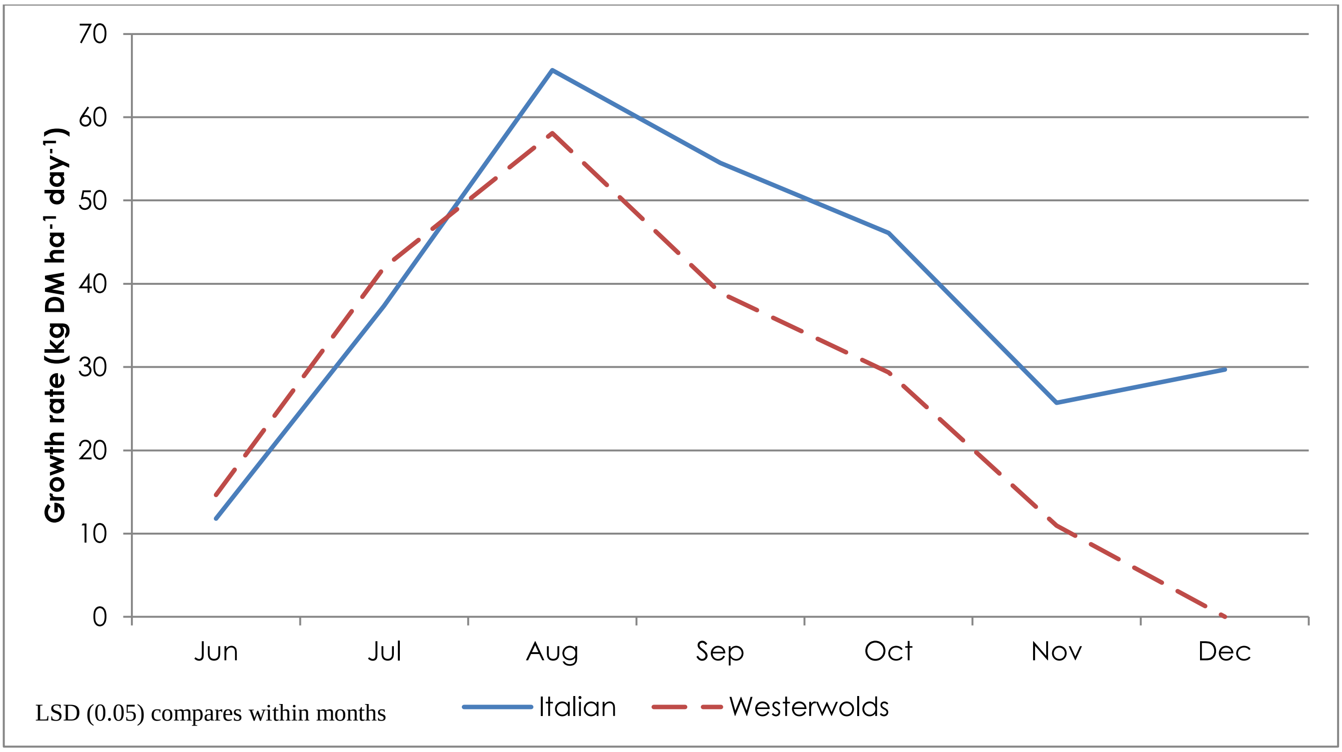


Figure 4b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during April

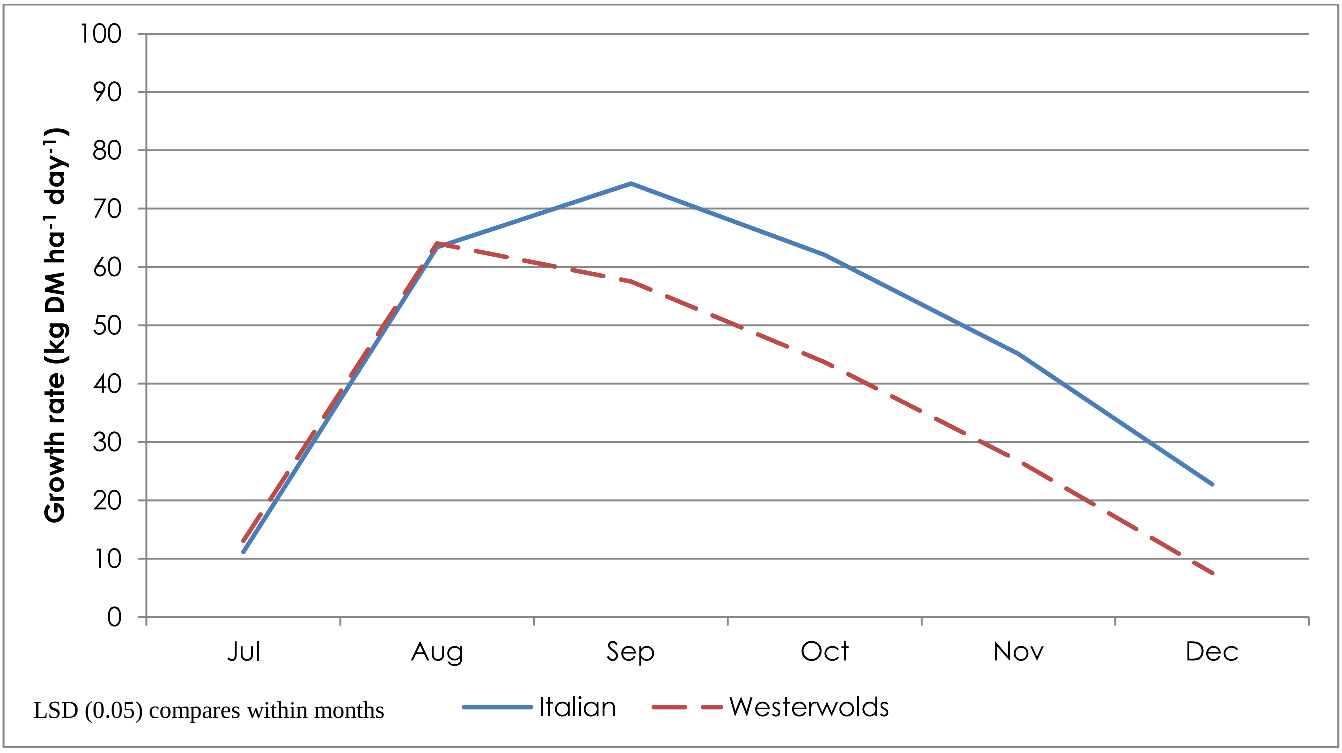


Figure 5b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during May

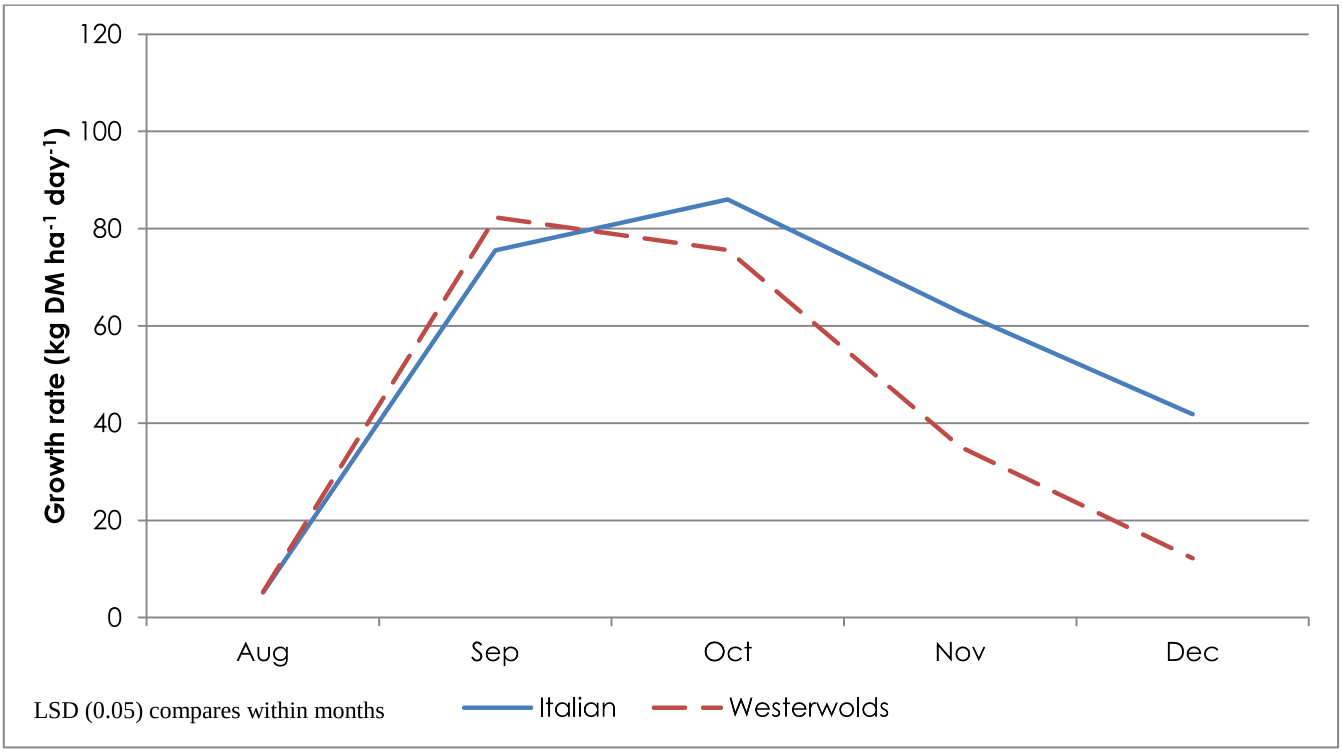


Figure 6b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during June

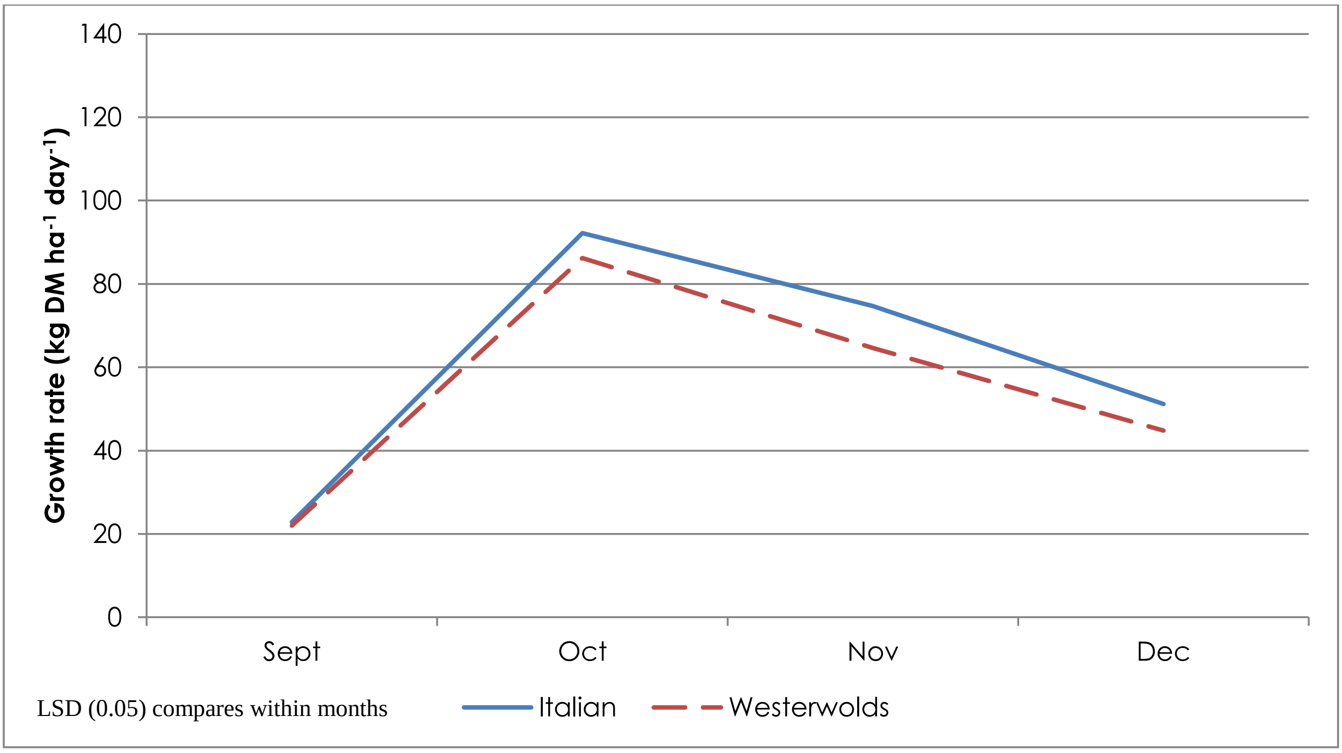


Figure 7b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during July

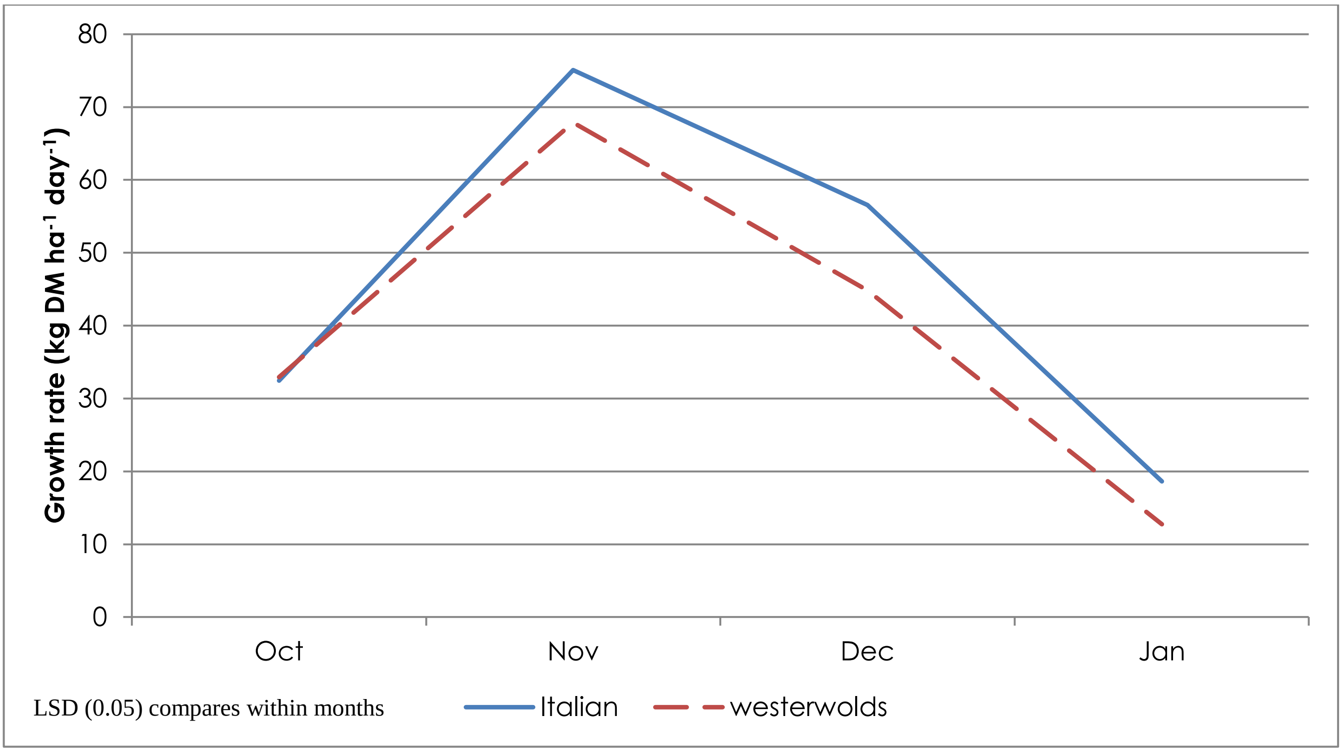


Figure 8b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during August

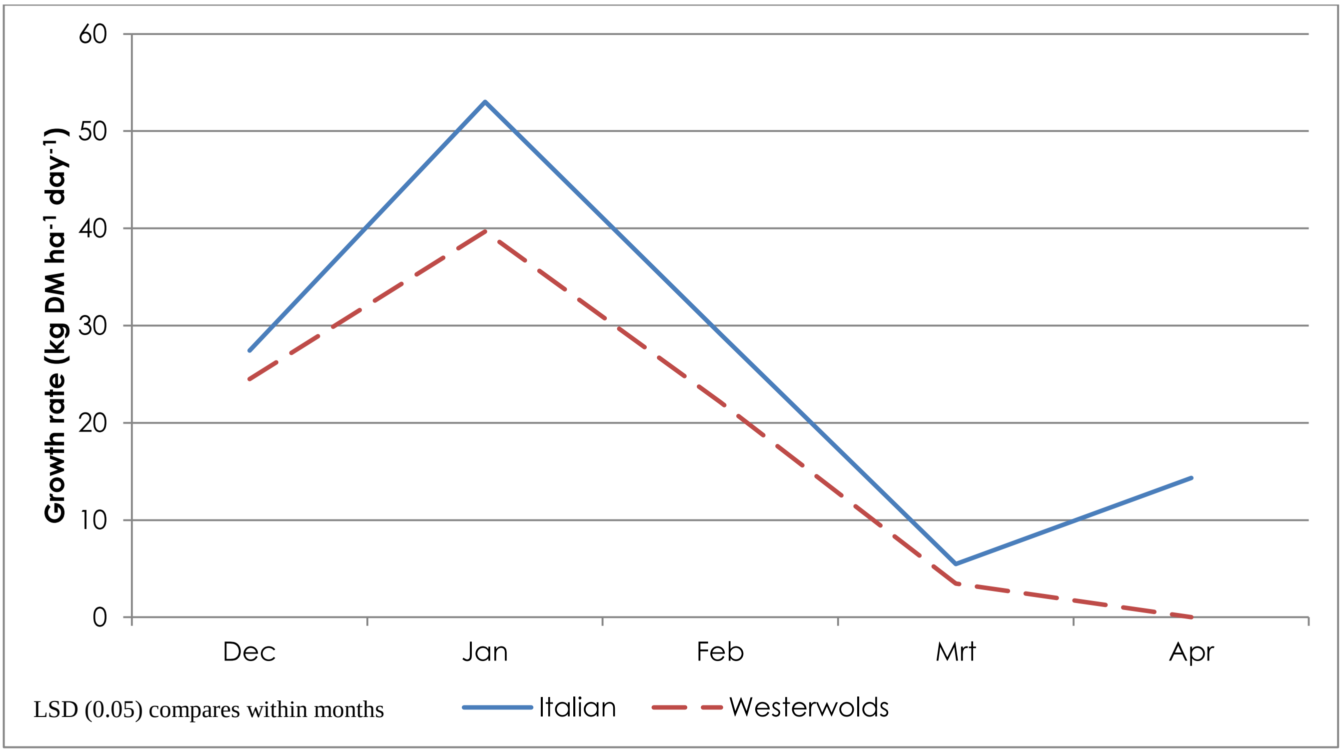


Figure 10b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during October

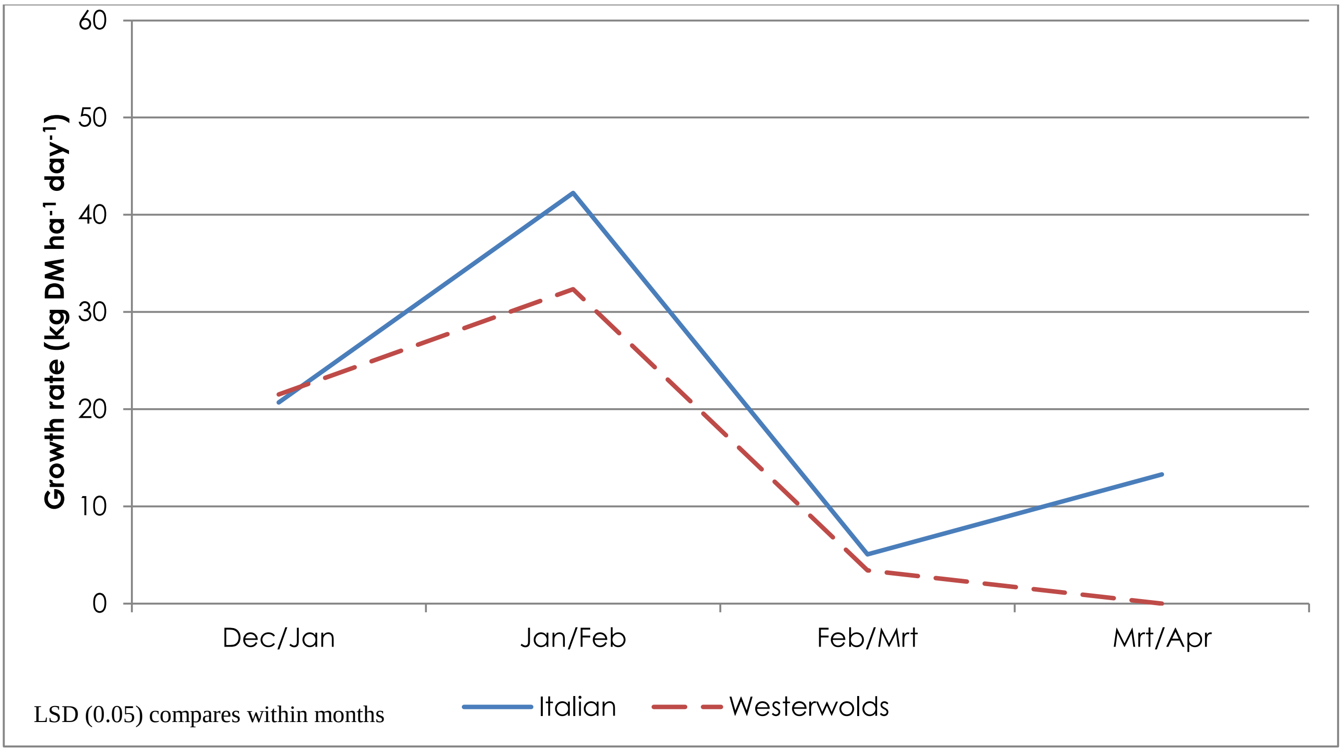


Figure 11b. Mean monthly growth rate of Italian and Westerwolds ryegrass planted during October

The average combined growth rate over two years for the two ryegrass varieties shows that Italian ryegrass had similar or higher growth rate than Westerwolds ryegrass at all planting dates. Italian ryegrass also had a more protracted growth pattern than Westerwolds ryegrass if planted from December until June. Planting dates from July until

November shows that the monthly growth between Italian and Westerwolds ryegrass differ less and that the total productive months for both varieties decline.

Table 2 shows the monthly growth rate (kg DM ha^{-1} day^{-1}) and total dry matter production (ton DM ha^{-1}) of Italian ryegrass planted at different planting dates.

Italian ryegrass was harvested nine times if planted during January, February or March with a total DM production of 9.3, 9.3 and 9.8 ton DM ha^{-1} respectively. The total harvests decreased monthly from 7 to 3 harvests if planted from April until September. The total DM production decreased during the same period from 8.3 to 3.6 ton DM ha^{-1}. The December planting date was harvested more than any of the other planting dates but the monthly growth rate from June until September and the total DM production (8.6 to DM ha^{-1}) were lower than the January, February and March planting dates for this critical winter period.

If the aim in a fodder flow program is to provide feed from May until November, which include the critical winter months (June, July and August), it is better to plant Italian ryegrass during January, February or March. The production will be spread over nine harvests with growth rates from 13 and 64 kg DM ha^{-1} day^{-1} and a total production of 9.3 and 9.8 ton DM ha^{-1}.

If the aim is to produce optimum spring and early summer (August to December) fodder, Italian ryegrass should be planted during April, May or June. The ryegrass will be productive for 5 to 7 months and the total DM production can vary between 5 and 7 ton DM ha^{-1}. However, Italian ryegrass planted from July until November will result in short periods (1-2 months) of high production (up to 75 kg DM ha^{-1} day^{-1}) but the total DM production over the growth period will be low and can vary between 2.5 and 7.6 ton DM ha^{-1}.

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

The Westerwolds ryegrass was harvested nine times if planted during January and eight times if planted during February or March with a total DM production of 6.5, 7.7 and 7.5 ton DM ha^{-1}, respectively. The amount of harvests decreased monthly from 6 to 3 harvests if planted from April until September. The total DM production decreased during the same period from 5.9 to 4 ton DM ha^{-1} to as low as 2.8 and 1.7 ton DM ha^{-1} if planted during October or November. The December planting date produced 8 harvests but although the April growth rate was higher and May growth rate similar to that of the other planting dates, the monthly growth rates during June, July and August was low. The total DM production (5.2 ton DM ha^{-1}) was also lower than the total production (5.9 – 7.7 ton DM ha^{-1}) of the January until July planting dates. If planted during December it can be expected that Westerwold ryegrass, as a pasture, will not be productive from September onwards. This will have an adverse effect on the fodder flow program since this data also shows that the September until November planting dates are the worst period to establish Italian or Westerwolds ryegrass and feed shortages can be expected.

If the aim is to plant Westerwolds ryegrass as fodder from May until November, which include the winter months (June, July and August), it is better to plant Westerwolds ryegrass during January, February or March. The production will be spread over 8-9

Table 2: The monthly growth rate (kg DM $ha^{-1}day^{-1}$) and total DM production (ton DM ha^{-1}) of Italian ryegrass planted at different planting dates.

Planting date	**Monthly growth rate (kg DM ha^{-1})**																**Total production (ton DM ha^{-1})**
	Jan	**Feb**	**Mrt**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mrt**	**Apr**	
December	5	21	31	31	38	24	20	16	45	52							**8.6**
January			14	21	38	30	25	31	50	64	33						**9.3**
February				17	43	36	27	32	47	49	37	19					**9.3**
March				13	37	35	33	48	53	47	24	31					**9.8**
April						12	37	66	55	46	26	30					**8.3**
May							11	63	74	62	45	23					**8.4**
June								51	76	86	63	42					**9.7**
July									23	92	75	51					**7.4**
August										32	75	57	19				**4.8**
September											41	77	45				**3.6**
October												27	53	29	6	14	**3.9**
November													21	42	5	13	**2.5**

harvests, varied between 8 and 46 kg DM ha^{-1} day^{-1} and total between 6.5 and 7.7 ton DM ha^{-1}.

If the aim is to produce optimum spring and early summer (August to December) fodder from Westerwolds ryegrass, it is better to plant during April, May, June or July. The ryegrass will be productive between 4 and 6 months and the total DM production will vary between 5.9 and 6.7 ton DM ha^{-1}.

Westerwolds ryegrass planted from August until November will only be productive for short periods (mostly 1 month) producing up to 68 kg DM ha^{-1} day^{-1} but the total production will be low and can vary between 1.7 and 4.9 ton DM ha^{-1}.

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

The total DM production (ton DM ha^{-1}) of the Italian ryegrass for the December until July planting dates was higher than that of the Westerwolds ryegrass. The total DM production of both the Italian and Westerwolds ryegrasses during the August, September, October and November planting dates were low and the difference in DM production between the two varieties small. This data shows that Italian ryegrasse is on a total DM production basis and irrespective of planting date, more productive than Westerwold ryegrass. The best plantings dates, depending on the requirements within the fodder flow program, are between December and July.

Conclusions

Planting date influenced the production potential of both Italian and Westerwolds ryegrasses. The combined average growth rate over two years of the two varieties shows that Italian ryegrass, planted from January until June, is more productive than Westerwolds ryegrasses.

The variation in growth rate during spring and early summer over years at similar planting dates is an indication that climatic factors and the presence of weeds can influence the production potential of these temperate grasses. This can be a risk for farmers and an important reason for selecting planting dates in such a way to insure that these crops are productive, have the potential to overcome climatic changes and the ability to compete with spring and summer weeds.

If the aim, from a fodder flow perspective, is to provide fodder from May until November, which also includes the critical winter months (June, July and August), Italian ryegrass is a better option than Westerwolds ryegrass if planted during January, February or March. If the aim is to produce optimum spring and early summer (August to December) fodder, Italian ryegrass should be planted during April, May or June.

Italian or Westerwolds ryegrasses should not be planted later than June. This will result in short productive periods (1-2 months) and the total production will be low.

Table 3: The monthly growth rate (kg DM ha^{-1}day^{-1}) and total DM production (ton DM ha^{-1}) of Westerwolds ryegrass planted at different planting dates

Planting date	**Monthly growth rate (kg DM ha^{-1})**															**Total production (ton DM ha^{-1})**
	Jan	**Feb**	**Mrt**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mrt**	
December	7	21	32	29	32	20	16	12								5.2
January			15	19	32	25	21	25	41	25	8					6.5
February				25	43	31	26	29	46	30	24					7.7
March				17	41	34	31	36	40	32	16					7.5
April						15	42	58	39	29	11					5.9
May							13	64	58	44	27	8				6.5
June								5	82	76	35	12				6.4
July									22	86	65	45				6.7
August										33	68	45				4.9
September											35	66	29			4.0
October												25	40	22	4	2.8
November													22	32	3	1.7

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

Ryegrass variety	Planting date and production rate (ton DM ha^{-1})											
	Dec	Jan	Feb	Mrt	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Italian	8.6	9.3	9.3	9.8	8.3	8.4	9.7	7.4	4.8	3.6	3.9	2.5
Westerwolds	5.2	6.5	7.7	7.5	5.9	6.5	6.4	6.7	4.9	4.0	2.8	1.7

Message to the farmer

Planting date has a pronounced effect on the production potential of Italian and Westerwolds ryegrass. Both these species should be planted at specific planting dates to provide feed within a fodder flow programme from May until November. The production potential of Italian or Westerwolds ryegrass planted from August until November is low and will probably not be cost effective under irrigation if fertilised with nitrogen. December as a planting date for Westerwolds ryegrass is risky and could result in fodder shortage during spring and early summer. If not strategically over-sown into perennial pasture, Italian ryegrass is a better option than Westerwolds ryegrass based on growth rate and total production.

References

Fulkerson WJ and Donaghy 2001. Plant-soluble carbohydrate reserves and senescence – key criteria for developing an effective grazing management system for ryegrass-based pasture: a review. Australian Journal of Experimental Agriculture. 41: 261-275.

Soil Classification Workgroup 1991. Soil Classification, a Taxonomic system for South Africa. Memoirs on the Natural Agricultural Resources of South Africa. Nr 15. Department of Agricultural Development, Pretoria.

Ott RL 1993. An Introduction to Statistical methods and data analysis. Belmont, California:Duxbury Press: pp 807-837 (pp 1-1051)

SAS Institute, Inc. 2008. SAS Version 9.2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Shapiro S S and Wilk M B 1965. An Analysis of Variance Test for Normality (complete samples)., Biometrika, 52, 591-611.

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

OVERCOMING ROUGHAGE SHORTAGES DURING THE WINTER MONTHS IN THE SOUTHERN CAPE OF SOUTH AFRICA

L Steyn[1, 2], R Meeske[1] & CW Cruywagen[2]

[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George

[2]University of Stellenbosch, Department of Animal Science

Introduction

Kikuyu over-sown with ryegrass is the most widely used pasture system in the southern Cape of South Africa. As kikuyu remains dormant during the winter months (June to September), ryegrass is over-sown to fill the fodder flow gap during these months. For this purpose annual ryegrass types are preferred over perennial ryegrass types as the perennial ryegrass only establishes well into the spring and is unable to support intensive grazing during the coldest of the winter months (Dickinson *et al.*, 2004; Van der Colf, 2011). Due to the low temperatures and low light intensities experienced in the southern Cape region during the winter months the growth of the ryegrass pasture is slightly inhibited and growth rates can be as low as 30 kg DM ha^{-1}, where growth rates can be as high as 70 kg DM ha^{-1} during the summer (Fulkerson & Donaghy, 2001; Dickinson *et al.*, 2004). During the winter months ryegrass pasture is characterised as having a very high nutritive content, low concentration of structural components and a low dry matter (DM), this translates into high crude protein and non-structural carbohydrates (NSC) concentrations and low neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentrations (Meeske *et al.*, 2006; Van der Colf, 2011).

Due to the low growth rate of ryegrass pasture during the winter months the pasture has a longer growth cycle and takes longer to mature, resulting in roughage shortages. Two main strategies have been developed over the years to overcome these roughage shortages, namely feeding additional lucerne hay or some type of silage. Lucerne has to be bought in from outside and the cost is very high (R 1800 - 2400 ton^{-1}). The price of lucerne hay varies widely according to quality and demand, further complicating the financial planning during the already difficult winter months. Smaller farms often do not have the capacity to store a large amount of lucerne hay. Silage can also be bought in for additional feeding but is not always readily available and is also costly. Ideally excess pasture or a cereal crop should be ensiled on the farm itself, but many farms do not have the implements or excess roughage available for this. Lucerne hay or silage is then commonly fed using ring feeders and resulting in 10 - 20 % wastage. In addition to the feeding of lucerne hay or silage, cows are put out to graze for half of the day as well as receiving a concentrate supplement in the milking parlour. Concentrate supplements often have a high energy content which is readily available to the cow. This is achieved by including high levels of maize in the concentrate which results in a high price at which such a concentrate supplement is available (Bargo *et al.*, 2003). The return on milk production reduces as level of concentrate feeding increases.

An alternative strategy to overcome roughage shortages during the winter months has recently been investigated at the Outeniqua Research Farm. It has been shown that it is possible to replace a high starch concentrate supplement that is highly digestible with a low starch and high fibre concentrate supplement that is less digestible without negatively impacting milk production or rumen health (Lingnau, 2011). The lower digestibility of the high fibre concentrate supplement and the high NDF concentration helps to maintain the pH of the rumen, optimising microbial activity. Due to these characteristics of a high fibre concentrate supplement it is possible to feed this concentrate supplement at higher levels at the expense of pasture intake (Bargo *et al.*, 2003). Pasture is the cheapest feed source available and should therefore be used to its full potential, however the lower pasture availability during the winter months provides a gap in the feeding program. As such the aim of the study was to determine whether feeding a high fibre concentrate supplement at higher levels and restricting pasture allowance would be able to maintain a high level of milk production and rumen health as well as overcoming the winter roughage shortages.

Materials and Methods

The study was carried out at the Outeniqua Research farm near George in the Western Cape of South Africa. The farm is situated at 22° 25' 222" E and 33° 58' 702" S. The mean temperatures experienced during the study were: maximum = 18.85 °C and minimum = 7.92 °C (ARC, 2011). The area received 247 mm rainfall during the study period (ARC, 2011). The study was conducted from July 2011 to September 2011, spanning over a total of 92 days. A total area of 8.876 ha was used during the research period. The pasture consisted of kikuyu (*Pennisetum clandestinum*) over-sown with annual Italian ryegrass (*Lolium multiforum*). The kikuyu portion of the pasture remained dormant during the research period (winter and early spring months); therefore mainly ryegrass was available to cows. The soil of the 8.876 ha area used for the study was characterised by a Katspruit soil form, of the family Lammermoor. The each camp was fertilised with 42 kg N (LAN, limestone ammonium nitrate) ha^{-1} after each grazing.

Forty eight lactating Jersey cows were blocked according to 4 % fat corrected milk yield (19.09 ± 2.23 kg), days in milk (103.9 ± 62.66) and lactation number (4.38 ± 1.82). Cows within blocks were then randomly allocated to one of the three treatment groups. Treatment groups were defined according to the amount of high fibre concentrate supplement allocated as well as the level of pasture allocated (Table 2).

Table 2: Treatment group specifications according to high fibre concentrate supplement intake and pasture allowance

Parameter[1]	Treatment[2]		
	LC	MC	HC
Concentrate supplement intake (kg as is day^{-1})	4	7	10
Pasture allowance (kg DM day^{-1})	10	7	5
Farmlet size (ha)	3.57	2.92	2.2

[1] DM- Dry matter
[2] LC- Low concentrate; MC- Medium concentrate; HC- High concentrate

Table 3: Ingredient and chemical composition of the high fibre concentrate supplement fed to all three high fibre concentrate supplement treatment groups

Ingredient	g kg^{-1} (DM[1])
Finely ground maize	130
Hominy chop	300
Wheat bran	391
Gluten 20	100
Molasses	40
Feed lime	22
Salt	6
Acid buff	6
Premix[2]	5
Nutrient	**g kg^{-1} (DM)**
Dry matter	898.84
Crude protein	145.30
Rumen undergradable protein (% CP)	380.79
Metabolisable energy (MJ ME/kg DM)	10.94
Neutral detergent fibre	230.61
Acid detergent fibre	87.21
Ether extract	41.59
Ash	74.07
Calcium	12.38
Phosphorous	6.94
Magnesium	3.82

[1] DM - Dry matter
[2] Premix - 4 mg kg^{-1} Copper; 10 mg kg^{-1} Manganese; 20 mg kg^{-1} Zinc; 0.34 mg kg^{-1} Iodine; 0.2 mg kg^{-1} Cobalt; 0.06 mg kg^{-1} Selenium; 6 x 10^6 IU Vitamin A; 1 x 10^6 IU Vitamin D_3; 8 x 10^3 IU Vitamin E

The composition as well as nutritive content of the high fibre concentrate which was fed during the study is shown in Table 3. Eight cannulated Jersey cows were also used in the study. Cows were divided into two groups and allocated to either the LC or HC treatment group. They were used in a cross-over design, where all cows were subjected to both treatment groups LC and HC.

The three treatment groups were grazed separately, allowing for the pasture intake to be monitored and restricted. The total area of 8.876 ha was divided into 24 camps and each camp was divided into two lanes. Each lane was measured before grazing using the Rising plate meter (RPM) method as first described by Castle (1976). The linear regression equation: $Y = 77.1 * H - 530$, where Y = DM yield and H = RPM reading, was used to estimate the kg DM of pasture available per lane (Van der Colf, 2011). The total kg DM pasture available per lane, the pasture intake allocated to each treatment group and the number of cows per treatment group was then used to determine the number of breaks in which the specific lane could be divided and grazed. Once the pasture had been measured and the number of grazings calculated, polywire was used to lay out the strips for each grazing.

Once a lane of a camp had been grazed and the treatment group had been moved to the next lane the pasture yield was again measured using the RPM. During the adaptation period the reading obtained from the RPM was used to determine how well the pasture had been utilized and how accurately the regression equation was able to allocate pasture. A reading between 10 and 12 is indicative of a pasture which had been utilized well; not too much pasture was wasted, neither was the pasture over grazed.

Milk yield was measured at every milking session and milk samples were collected every second week. Pasture and high fibre concentrate supplement samples were collected on a weekly basis and pooled over two weeks for analysis at a later stage. Live weight and body condition score were also recorded at the commencement and completion of the study. A rumen study was carried out where rumen pH and rumen activity was determined.

The cows used in the production study were subjected to a randomised complete block design and cows used in the rumen study were subjected to a cross over design. All data collected during the study were subjected to an appropriate analysis of variance (ANOVA). This was done with the aid of the GLM procedure of SAS, Version 9.2 (SAS, 2008).

The null hypothesis was: Ho: $\mu_1 = \mu_2 = \mu_3 = \mu_{a.}$ The null hypothesis was rejected where $p < 0.05$. Student's t tests were used to confirm the results of the ANOVA and compare the treatment means at a 5 % significance level. Least squares means were used to calculate a pooled standard error of treatment means. Shapiro-Wilk tests were used to test for normality (Shapiro & Wilk, 1965).

Results and Discussion

Milk yield results are recorded in Table 4. Treatment group HC produced more milk than treatment group LC as was expected, due to the higher level of metabolisable energy consumed. It is known that the increase in milk production per kg concentrate supplement decreases as the level of concentrate supplement feeding increases (Kellaway & Harrington, 2044; Sairanen *et al.*, 2006) As such the milk response of treatment group HC was not remarkable compared to treatment group LC and did not differ at all from treatment group MC.

Milk composition data collected during the study is recorded in Table 4. The milk fat % of treatment group LC and MC did not differ, but were high according to breed standards. This is due to the high NDF concentration of the high fibre concentrate supplement, which results in increased acetate and butyrate production ultimately increasing the milk fat % (McDonald *et al.*, 2000; Bargo *et al.*, 2003; Lingnau, 2011). However the milk fat % of treatment group HC was lower than that of treatment group LC and MC. This is as a result of the high levels at which the concentrate supplement was fed; when a concentrate supplement (even a high fibre concentrate) is fed at such high levels a drop in rumen pH is experienced and cellulolytic bacteria become less active, acetate and butyrate concentration decreases and milk fat % decreases (Hoover, 1986; Van Soest *et al.*, 1991). Milk protein % does not respond readily to dietary manipulation (Bargo *et al.*, 2003; Kellaway & Harrington, 2004), as such no differences were found between either of the treatment groups. Somatic cell count (SCC) did not differ between either of the treatment groups; udder health was maintained even under high stocking rates.

Changes in body condition score (BCS) are shown in Table 4. BCS change did not differ between either of the treatment groups. BCS did improve slightly for all three treatment groups which is expected of cows in mid to late lactation.

The rumen data collected during the rumen study period are shown in Table 5. The total VFA concentration of treatment group LC and HC did not differ; although the acetate concentration as well as the acetate to propionate ratio of treatment group HC was lower than treatment group LC. This corresponds to the lower milk fat % of treatment group HC. There was no difference in the pH of the rumen of the two treatment groups or in the NH_3-N concentrations. This all indicates that rumen function and health were maintained even at such high levels of concentrate supplement and low pasture allowance levels.

Pasture allowance was lower for treatment group HC than for treatment group MC and LC and pasture allowance for treatment group MC was lower than for treatment group LC. Lower pasture allowance corresponds to a higher stocking rate; this is reflected in Table 6. The % pasture saved was calculated in relation to treatment group LC, which is typical of the grazing situation during the summer months. The pasture requirement of cows on the HC and MC treatment was reduced by 36.7 % and 22.3 % respectively during the winter months compared to the LC treatment.

Table 4: Mean milk yield and milk composition parameters (fat, protein, lactose, SCC and MUN) as well as LW and BCS of cows before and after the study of all three high fibre concentrate supplement treatment groups

Parameter[1]	Treatment[2]			SEM[3]	p-value
	LC	MC	HC		
Milk yield (kg cow^{-1} day^{-1})	16.18[a]	17.25[ab]	18.12[b]	0.486	0.029
4 % FCM (kg cow^{-1} day^{-1})	18.37	19.66	19.6	0.473	0.110
Fat (%)	4.92[a]	4.96[a]	4.58[b]	0.092	0.014
Protein (%)	3.61	3.63	3.54	0.042	0.306
Lactose (%)	4.67[a]	4.63[a]	4.5[b]	0.028	< 0.001
SCC (x 1000 mL^{-1})	174.8	211.26	206.13	24.842	0.602
MUN (mg dL^{-1})	11.62[a]	11.55[a]	9.95[b]	0.369	0.004
BCS before	2.34	2.30	2.23	0.062	0.461
BCS after	2.66	2.58	2.42	0.107	0.301
BCS change	0.31	0.28	0.19	0.082	0.537

[1] FCM- Fat corrected milk; SCC- Somatic cell count; MUN- Milk urea nitrogen; BCS- Body condition score
[2] LC- Low concentrate; MC- Medium concentrate; HC- High concentrate
[3] SEM- Standard error of the mean
[a, b] Means in the same row with different superscripts differ ($p < 0.05$)

Table 5: Average daily total volatile fatty acid, acetate, propionate, butyrate and ammonia nitrogen concentration as well as acetate: propionate ratio and pH of the rumen of eight cannulated Jersey cows grazing kikuyu-ryegrass pasture

Parameter[1]	Treatment[2]		SEM[3]	p-value
	LC	HC		
Total VFA (mM L^{-1})	58.03	55.42	1.1730	0.167
Acetate (mM L^{-1})	30.04[a]	25.98[b]	0.7001	0.006
Propionate (mM L^{-1})	11.83	12.65	0.3763	0.173
Butyrate (mM L^{-1})	8.31	8.42	0.4098	0.850
Acetate : Propionate	2.67[a]	2.15[b]	0.0863	0.005
pH	6.38	6.11	0.1270	0.286
NH_3-N (mg dL^{-1})	24.82	23.26	1.6545	0.529

[1] VFA- Volatile fatty acids; NH_3-N- Ammonia nitrogen
[2] LC- Low concentrate; HC- High concentrate
[3] SEM- Standard error of the mean
[a, b] Means in the same row with different superscripts differ ($p < 0.05$)

Table 6: The mean stocking rates and % pasture saved of three high fibre concentrate supplement treatment groups

Parameter	Treatment[1]			SEM[2]	p-value
	LC	MC	HC		
Stocking rate (cows ha^{-1})	5.07[a]	6.07[b]	7.64[c]	0.278	<0.001
% Pasture saved	0	22.3	36.7	-	-

[1] LC - Low concentrate; MC - Medium concentrate; HC - High concentrate
[2] SEM - Standard error of the mean
[a, b] Means in the same row with different superscripts differ ($p < 0.05$)

Economic evaluation

The economic evaluation was done on a herd size of 300 Jersey cows, which is the average herd size of dairy farms in the Southern Cape of South Africa. Milk production for the three treatment groups shown in Table 7 depicts the actual milk production obtained during the study. The milk production for the grass silage and lucerne hay strategies was estimated. The milk price for the three treatment groups was received from Nestlé and the influence of milk fat % on the milk price is evident; higher milk fat % results in a higher milk price. The milk price for the grass silage and lucerne hay strategies as shown in Table 7 reflects the actual milk price which was obtained by the large herd of the Outeniqua Research farm during the winter months of 2012. The high fibre concentrate supplement price of the three treatment groups was obtained from NOVA feeds and includes the cost of the premix as well. The price of the concentrate supplement provided to cows on the grass silage and lucerne hay strategies reflects the actual cost of the concentrate supplement fed to the large herd of the Outeniqua Research farm during the winter months of 2012. The supplement prices for the grass silage and lucerne hay are estimated values that can vary over a large price range. Producing grass silage at a cost higher than R 1300 per ton will not prove economically viable under any circumstances. The lucerne hay price also varies a lot and can increase to as much as R 2400 per ton. The price of 1 kg pasture was obtained from the Outeniqua Research Farm during the winter months of 2012. The net daily and monthly profit only depicts the margin above feed costs and does not take any labour, machinery or any other farm related costs into consideration.

As the study only included the LC treatment group, MC treatment group and HC treatment group the results obtained cannot be compared on a statistical or scientifically sound level to the grass silage and lucerne hay strategies. However from a practical view point it is of the utmost importance to know whether the high fibre concentrate supplement and pasture restriction is economically viable or not, compared to current strategies.

Table 7: Profit as calculated for margin above feed costs for all three high fibre concentrate supplement treatment groups as well as estimated for two current strategies to overcoming winter roughage shortages

Parameter	Treatment			Grass silage + concentrate + pasture	Lucerne hay + concentrate + pasture
	LC	MC	HC		
Milk yield (kg cow^{-1} day^{-1})	16.18	17.25	18.12	16	16
Milk yield (kg 300* $cows^{-1}$ day^{-1})	4854	5175	5436	4800	4800
Milk fat %	4.92	4.96	4.58	-	-
Milk price (R** L^{-1})	3.90	3.92	3.77	3.76	3.76
Milk income (R 300 $cows^{-1}$ day^{-1})	18931	20286	20494	18048	18048
Concentrate price (R ton^{-1})	2725	2725	2725	3060	3060
Concentrate inclusion level (kg)	4	7	10	5	5
Concentrate price (R cow^{-1} day^{-1})	10.9	19.08	27.25	15.3	15.3
Concentrate price (R 300 $cows^{-1}$ day^{-1})	3270	5723	8175	4590	4590
Supplement price (R ton^{-1})	0	0	0	1300	2000
Supplement inclusion level*** (kg)	0	0	0	5	5
Supplement price (R cow^{-1} day^{-1})	0	0	0	6.5	10
Supplement price (R 300 $cows^{-1}$ day^{-1})	0	0	0	1950	3000
Pasture price (R kg^{-1})	1	1	1	1	1
Pasture allowance (kg DM)	10	7	5	5	5
Pasture price (R cow^{-1} day^{-1})	10	7	5	5	5
Pasture price (R 300 $cows^{-1}$ day^{-1})	3000	2100	1500	1500	1500
Total feed output cost	6270	7823	9675	8040	9090
Net daily margin over feed cost	12661	12464	10819	10008	8958
Net monthly margin over feed cost	379818	373905	324562	300240	268740

* 300 cows - Average herd size in the Southern Cape of South Africa
** R - South African currency, rand
*** Supplement inclusion level - does not take wastage of 10 - 20 % into consideration

The net monthly profit of treatment group HC is lower than that for treatment group LC and treatment group MC. This is due to a combination of factors. Treatment group HC had a lower milk fat % and received a lower milk price accordingly. Treatment group HC also consumed more than twice the amount of HF concentrate supplement compared to treatment group LC, and as pasture is always the cheapest feed source, this contributed to the lower net monthly profit. However treatment group HC did produce more milk than treatment group LC and this helped to lower the difference in net monthly profit. Treatment group LC represents the ideal situation and will not be obtainable during the winter months due to pasture shortages. To determine whether the strategy of treatment group HC is economically viable it must be compared to alternative current strategies.

When treatment group HC is compared to the grass silage and lucerne hay strategies there is a definite increase in net monthly profit. R 24 322 can be saved per month when compared to feeding grass silage and R 55 822 can be saved when compared to feeding lucerne hay. The price of lucerne hay and the cost of implements for ensiling will all influence the net monthly profit and will determine whether the HC treatment group strategy is more economically viable than the grass silage and lucerne hay strategies. One factor that will remain in the favour of the HC treatment group strategy is the lower cost of a high fibre based concentrate supplement compared to a high starch based concentrate supplement, including less maize will always lower the price.

Conclusions

Milk production was increased when cows were fed such high levels of a high fibre concentrate, while limiting pasture intake. Milk composition was slightly compromised, which was reflected in the milk price. Overall cow health and rumen health was maintained as can be seen from the increase in BCS and the rumen data. By lowering pasture intake, it is possible to pace the grazing of pasture to match the slower growth cycle of pasture, i.e. one will not 'run out of' pasture. The higher levels of high fibre concentrate feeding did increase the time cows spent in the milking parlour, although cows were able to adapt within 4 - 5 weeks after the new feeding program was started. It is economically viable to feed higher levels of the high fibre concentrate and restrict pasture intake compared to feeding lucerne hay or grass silage additionally. As such it is possible to overcome roughage shortages during the winter months by feeding high levels of a high fibre concentrate supplement and lowering pasture allocation.

References

ARC, 2011. Agro-Climatology database. The ARC's Institute for Soil Climate and Water, Dept of Agro-Climatology. I.O. van Gent, vgenti@ arc.agric.za

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

Castle, M. E., 1976. A simple disc instrument for estimating herbage yield. Grass Forage Sci. 31(1): 37

Dickinson, E.B., Hyam, G.F.S., Breytenbach, W.A.S., Metcalf, H.D., Basson, W.D., Williams F.R., Scheepers, L.J., Plint, A.P., Smith, H.R.H., Smith, P.J., van Vuuren, P.J., Viljoen, J.H., Archibald, K.P. & Els, J.H., 2004. Kynoch pasture handbook. Cape Town, SA.

Fulkerson, W.J. & Donaghy, D.J., 2001. Plant soulble 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.

Hoover, W.H., 1986. Chemical factors involved in ruminal fibre digestion. J. Dairy Sci. 69(10): 2755

Kellaway, R. & Harrington, T., 2004. Feeding concentrates: Supplements for dairy cows. Daiy Australia, Land Links publisher.

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

Meeske, R., Rothauge, A., Van der Merwe, G.D. & Greyling, J.F., 2006. The effect of concentrate supplementation on the productivity of grazing jersey cows on a pasture based system. S. Afr. J. Anim. Sci. 36(2): 105-110.

McDonald, P., Greenhalgh, J.F.D. & Morgan C.A., 2002. Animal nutrition. Sixth ed. Addison-Wesley Longman

Sairanen, A., Khalili, H. & Virkajarvi, P., 2006. Concentrate supplementation responses of the pasture-fed dairy cow. Livestock Sci. 104: 292–302.

SAS Institute, Inc. (2008). SAS Version 9.2., SAS Campus Drive, Cary, North Carolina 27513

Shapiro, S.S. & Wilk, M.B., 1965. An analysis of variance test for normality. Biometrika 52(3/4):.

Van der Colf, J., 2011. The production potential of kikuyu (*Pennisetum clandestinum*) pastures over-sown with ryegrass (*Lolium* spp.). MSc thesis, University of Pretoria, South Africa.

Van Soest, P. J., Robertson, J. B. & Lewis, B. A., 1991. Symposium: Carbohydrate methodology, metabolism and nutritional implications in dairy cattle. J. Dairy Sci. 74(10): 3583-3597.

PALM KERNEL EXPELLER AS SUPPLEMENT FOR DAIRY COWS GRAZING KIKUYU/RYEGRASS PASTURE

JDV van Wyngaard[1, 2], R Meeske[1], L J Erasmus[2]

[1] Western Cape Department of Agriculture, Outeniqua Research Farm, George

[2] University of Pretoria, Department of Animal and Wildlife Sciences, Pretoria

Introduction

The number of milk producers in South Africa has decreased by 36 % from January 2007 to January 2012 (Coetzee, 2012). The Western Cape has the highest number of milk producers and producer-distributors, as well as the second highest number of milk buyers compared to the other provinces of South Africa (Coetzee, 2012). This decrease in milk producers places great pressure on the prevailing milk producers to satisfy the ever increasing demand for milk and milk products. Low milk prices and increased input costs amplify the financial pressure experienced by today's dairy farmer, not even mentioning the pressure of lowering their carbon footprint.

Improving the efficiency of production and reducing the cost of concentrate supplements for dairy cows are becoming increasingly important for the dairy farmer. Dairy concentrates contribute up to 66 % of the total feed cost in pasture grazing systems according to Meeske *et al.* (2006). High maize and oilcake prices have a substantial impact on milk production costs. Maize grain can constitute up to 70 to 80 % of a conventional dairy concentrate and soybean oilcake can constitute up to 8 to 12 % of the concentrate (Meeske *et al.*, 2009), both of these feed sources are expensive. When the maize price is high, replacing maize with lower cost high fibre by-products becomes an economically viable option.

In a study previously carried out at the Outeniqua Research Farm it was shown that maize, in the concentrate supplement of dairy cows, can be replaced by high fibre by-products such as hominy chop, gluten 20 and bran without causing a reduction in milk production and actually resulting in an increase in milk fat content (Lingnau *et al.*, 2010). Input cost can be markedly reduced by replacing a starch-based concentrate with a fibre-based concentrate (Muller *et al.,* 2001). A fibre-based concentrate also results in an increase in pasture intake and total dry matter intake (Meijs, 1986; Sayers, 1999) and is able to sustain or even increase milk production and milk fat percentages for dairy cows grazing ryegrass pasture (Meijs, 1986; Sayers, 1999; Delahoy *et al.*, 2003).

Palm kernel expeller (PKE) is a low cost, high fibre residue or by-product from the palm kernel oil extraction process of the African Palm Seed (Abdullah & Hutagalung, 1988; Carvalho *et al.*, 2006; Chanjula *et al.*, 2011). The African Palm seed is produced mainly from three equatorial tropics; South-East Asia, South America and Africa. The neutral detergent fibre (NDF) content of PKE is high (69 %) and is therefore regarded as a high fibre by-product. The crude protein content of PKE is 17 % which is higher than that of maize grain (7 %). Most of the energy of PKE comes from the oil and NDF content. As PKE is very low in starch and sugars, this lowers the risk of developing acidosis and other rumen health disorders (Varga *et al.*, 1998). Palm kernel expeller is invaluable in supplying protein to ruminants, and most of the common minerals are within the acceptable ranges (Alimon, 2004). According to Zahari & Alimon (2003) PKE is used as a source of energy and fibre for dairy cows at inclusion levels of 30 – 50 %, however Carvalho *et al.* (2006) states that PKE is generally included in small amounts (< 10 %) in dairy concentrates due to its low palatability. Palm kernel expeller is mainly used as a pasture extender in Australia and New Zealand when pasture growth rate is low.

The aim of this study was to determine the effect of partially replacing maize with PKE in concentrates for dairy cows on milk production, milk composition, live weight and body condition score of cows grazing ryegrass pasture during spring.

Materials and methods

The study was conducted at the Outeniqua Research Farm situated near George in the Western Cape Province of the Republic of South Africa (RSA). The altitude, latitude, and longitude are 204 meter above sea-level, 33°58´38´´S and 22°25´16´´E, respectively. The George area has a temperate climate. The long term mean rainfall in this area over a period of 45 years, since 1967, is 731.45 mm per annum (ARC 2011). The study took place from the 12th of August 2011 to the 1st of November 2011. The paddock where the study was conducted consisted of 8.55 hectares of permanent irrigated Kikuyu (*Pennisetum clandestinum*) and annual ryegrass (*Lolium multiflorum* var. *italicum*) pasture (annual ryegrass being the dominant stand during the study period) and characterized by two distinct soil forms namely an Estcourt form in the northern part of the paddock and a Witfontein form in the slightly downward sloping southern part (Soil Classification Working Group, 1991). Manual tensiometers were used to schedule the irrigation of the paddock. Irrigation was initiated at a tensiometer reading of -25 Kpa and was ended at a reading of -10 Kpa (Botha, 2002). The paddock was divided into thirty nine strips, where each strip had a length of 150 m and a width of 15 m. Each strip was top-dressed with 42 kg nitrogen (LAN, limestone ammonium nitrate) per hectare after each grazing. Pasture dry matter (DM) yield per area was estimated by using the rising plate meter (RPM) with a disk area of 0.098 m^2, by taking the mean of 100 RPM readings in a zigzag pattern on each pasture strip the day before and after grazing. A seasonal regression was used as part of the pasture DM yield measurement.

Forty eight multiparous, high producing Jersey cows [4 % fat corrected milk (FCM), 27.2 ± 4.1 kg day^{-1}; days in milk (DIM), 83.5 ± 41.3; lactation number, 3.9 ± 1.8; (mean ± SD)] were blocked according to FCM, DIM and lactation number and randomly allocated to three treatments (control, low PKE and high PKE). The PKE inclusion in the control, low PKE and high PKE treatment concentrates was 0, 20 and 40 %, respectively. The PKE replaced part of the maize and protein sources in the concentrate. Milk yield was recorded daily and milk composition was determined in two week intervals over a 60 day period, after a 21 day adaptation period (7 days on the pasture with *ad libitum* access to PKE followed by 14 days of feeding allocated treatments in the milking parlour). Additionally, eight rumen cannulated, lactating dairy cows were randomly allocated to the control and high PKE treatment in a two period crossover design. Rumen pH, volatile fatty acids (VFA), and rumen ammonia nitrogen (NH_3-N) were measured.

Cows received 6 kg (as is basis) of the allocated treatment concentrate per day split over two milking periods and strip grazed the pasture, which was allocated at 10 kg DM cow^{-1} day^{-1} above 30 mm (RPM reading of 6). An after-grazing height of 50 mm (RPM reading of 10) was maintained by adjusting the allocated kilogram DM pasture per cow given the DM yield per hectare calculated by the seasonal regression. Fresh drinking water was available *ad libitum* at all times.

The nutrient composition of PKE (imported from Indonesia by Pieter Brönn, Intelact (Pty) Ltd, Eastern Cape, 2011, pbronn@farmvision.co.za) was determined before treatment concentrates were mixed (Animal Production Laboratory, University of Stellenbosch, 2011) as shown in Table 1. Treatment groups only differed in the composition of the allocated concentrate (Table 2). Concentrates were balanced to be iso-nitrogenous. Molasweet (Nutec Explicit Nutrition, Block G, Hilton Quarry Office Park, 400 Old Howick Road, Hilton, KZN), a powdered palatant was added at 160 grams per ton to each of the three concentrate treatments to increase palatability.

NOVA feeds (Nova feeds George, Industrial Area, George Western Cape, South Africa) formulated, mixed and bagged (50 kg) ten tons of each of the three treatment concentrates. The concentrates could not be pelleted, because the PKE inclusion levels exceeded that of NOVA feeds' recommendations and was therefore fed in a meal form. A maximum of 4 % PKE can be included in the feed for it to be pelleted due to the detrimental action of small stones in PKE on the pellet machine.

The production study data were analysed statistically as a randomized block design with three treatments randomly allocated to 16 blocks using the GLM model (Statistical Analysis System, 2012) for the average effects over time. The rumen study data were analysed statistically using the GLM model (Statistical Analysis System, 2012) in a cross-over design, which ensured that both treatments were present in both periods. Means and standard error were calculated and significance of difference ($p < 0.05$) between means was determined by Fischers test (Samuels, 1989).

Table 1 The nutrient composition of palm kernel expeller that was included at different levels in each of the three concentrate treatments fed to Jersey cows grazing kikuyu/ryegrass pasture in the spring

Nutrient[1] (DM basis)	**PKE[2]**
DM (%)	89.8
Ash (%)	4.7
CP (%)	19
NDF (%)	77.8
ADF (%)	55.2
EE (%)	10.2
Ca (%)	0.56
P (%)	0.74
Ca : P	0.76

[1] DM – Dry matter; CP – Crude protein; NDF – Neutral detergent fibre; ADF – Acid detergent fibre; EE – Ether extract; Ca – Calcium; P – Phosphorous; Ca : P – Ratio between calcium and phosphorous

[2] PKE – Palm kernel expeller

Results and Discussion

The rumen parameters of the cannulated cows that received 0 % PKE (control) and 40 % PKE (High PKE) inclusions in their concentrate are presented in Table 3. The total volatile fatty acid (VFA) concentration did not differ between treatments. This coincides with the findings of Bargo *et al.* (2003) and Ranathunga *et al.* (2010) where a fibre-based concentrate was compared with a starch-based concentrate. The specified VFA's, rumen NH_3-N and mean ruminal pH fell within the ranges specified by Bargo *et al.* (2003) for grazing cows supplemented with a concentrate, however none differed ($p > 0.05$) between treatments. Propionic acid did however show a tendency to differ between treatments. Sayers (1999) found that fibre-based concentrates increased the molar proportion of acetic acid and butyric acid, and decreased the molar proportion of propionic acid. The acetic to propionic acid ratio did differ ($p < 0.05$) between the treatments. This was as a result of the difference in the relative proportions of each of the VFA's compared to the total VFA concentration. This all indicates that rumen fermentation was maintained, resulting in a healthy rumen environment for both treatments.

Table 2: The ingredient and nutrient composition of each of the three treatment concentrates fed to Jersey cows grazing kikuyu/ryegrass pastures in the spring

Ingredient[1]	Treatment concentrates[2] (n = 4)			Pasture (n = 8)
	Control	Low PKE	High PKE	
Ground maize	81.6	65.7	49.9	
PKE	0	20	40	
Soybean oilcake	10.5	6.6	2.5	
Molasses	5	5	5	
Feedlime	1.5	1.4	1.3	
Salt	0.6	0.6	0.6	
MgO	0.3	0.25	0.2	
Vitamin and Mineral Premix[3]	0.5	0.5	0.5	
Nutrient[4] (DM bases)				
DM (%)	88.6	89.3	90.1	12.9
OM (%)	94.6	94.2	94.1	89.4
IVOMD (%)	92.0	87.2	81.6	80.2
ME (MJ kg^{-1})	13.2	12.7	12.2	11.5
CP (%)	12.3	12.1	12.3	21.5
NDF (%)	10.3	18.8	29.5	49.4
ADF (%)	4.13	10.5	18.2	30.2
ADL (%)	1.15	3.03	5.82	2.12
Starch (%)	60.8	51.0	39.5	1.32
EE (%)	2.62	3.92	5.39	12.5
Ca (%)	0.67	0.85	0.84	0.38
P (%)	0.29	0.34	0.39	0.34
Ca : P	2.31	2.48	2.12	1.12

[1] PKE – Palm kernel expeller; MgO – Magnesium oxide
[2] Control – 0 % PKE; Low PKE – 20 % PKE; High PKE – 40 % PKE
[3] Premix (Coprex Dairy Premix) – (per unit of premix) 6 million IU vitamin A; 1 million IU vitamin D3; 8000 IU vitamin E; 100 g zinc, 50 g manganese, 20 g copper, 1.7 g iodine; 1 g cobalt; 300 mg selenium
[4] DM – Dry matter; OM – Organic Matter; IVOMD – *In vitro* Organic Matter Disappearance; ME – Metabolisable energy; CP – Crude protein; NDF – Neutral detergent fibre; ADF – Acid detergent fibre; ADL – Acid Detergent Lignin; EE – Ether extract; Ca – Calcium; P – Phosphorous; Ca : P – Ratio between calcium and phosphorous
Molasweet added at 160 g ton^{-1} in each concentrate treatment

Table 3: Average daily ruminal volatile fatty acids, rumen NH_3-N, and pH measurements of eight cannulated Jersey cows fed 6 kg (as is) of allocated palm kernel expeller concentrate per day grazing kikuyu/ryegrass pasture in the spring

Rumen Parameter[1]	Concentrate treatment[3]		SEM[4]	P-value
	Control	High PKE[2]		
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
Butyric acid (mmol L^{-1})	17.3	16.5	0.67	0.43
Acetic : Propionic acid	3.22	3.40	0.03	< 0.01
NH_3-N (mg dL^{-1})	13.8	14.6	0.59	0.39
pH	6.42	6.33	0.08	0.48

[1] VFA – volatile fatty acids; NH_3-N – rumen ammonia nitrogen
[2] PKE – palm kernel expeller
[3] Control – concentrate containing 0 % PKE; High PKE – concentrate containing 40 % PKE
[4] SEM – standard error of mean

The milk production parameters are presented in Table 4. Milk yield and 4 % fat corrected milk did not differ ($p > 0.05$) between treatments. As PKE inclusion increased the maize inclusion decreased in the concentrate. This resulted in a lower metabolisable energy content in the concentrate as the PKE inclusion increased. Therefore it could be debated that the milk yield should have decreased as the PKE inclusion in the concentrate increased, but this was not found to be true. Several authors found similar milk yield responses of cows grazing pasture when fibre-based concentrates were compared to starch-based concentrates (Garnsworthy, 1990; Sayers, 1999; Delahoy *et al.*, 2003).

Milk fat percentage did not differ ($p > 0.05$) between treatments even though an increase in milk fat percentage was predicted in the low and high PKE treatments due to the higher NDF level of these concentrates. These findings were in agreement with other authors (Garnsworthy, 1990; Sayers, 1999; Delahoy *et al.*, 2003) who found no effect of fibre-based concentrates compared to starch-based concentrates on milk fat percentage. However, Sayers (1999) and Meeske *et al.* (2009) did find a difference ($p < 0.05$) in milk fat percentage between fibre- and starch-based concentrates. Milk protein percentage, somatic cell count (SCC), and milk urea nitrogen (MUN) did not differ ($p > 0.05$) between treatments. The milk lactose percentage of the high PKE treatment was higher ($p < 0.05$) than that of the control treatment. This could be correlated to the tendency of propionic acid to show a difference between the control and high PKE treatment groups. There was no difference ($p > 0.05$) in milk lactose percentage between the control and low PKE treatment groups. These results indicate that milk yield and milk composition of cows grazing kikuyu/ryegrass pasture can be sustained by including a high fibre by-product, such as PKE, with lower metabolisable energy levels in the supplemented concentrate.

Live body weight (LW) and body condition score (BCS) parameters are also depicted in Table 4. The LW and BCS did not differ ($p > 0.05$) between treatments. These results are similar to that found by several authors (Sayers, 1999; Meeske *et al.*, 2009; Lingnau *et al.*, 2010) indicating that concentrate supplementation has little effect on LW change or BCS change of lactating dairy cows. This indicates that cows did not lose LW or BCS at the expense of maintaining milk yield in the low and high PKE treatment groups, therefore the allocated pasture and concentrate provided sufficient energy to maintain the milk yield.

Table 4: Milk yield, milk composition, live body weight, body condition score, and average daily concentrate refusals of Jersey cows fed 6 kg (as is) of allocated palm kernel expeller concentrate per day grazing kikuyu/ryegrass pasture in the spring

Parameter[1]	**Treatment**[3]			**SEM**[4]	**p-value**
	Control	**Low PKE**	**High PKE**[2]		
Milk yield (kg cow^{-1} day^{-1})	21.3	21.3	20.7	0.68	0.78
4 % FCM (kg cow^{-1} day^{-1})	23.2	23.2	22.7	0.69	0.83
Milk Fat (%)	4.63	4.65	4.66	0.13	0.98
Milk Protein (%)	3.54	3.46	3.50	0.05	0.52
Milk Lactose (%)	4.73^{a}	4.66^{ab}	4.58^{b}	0.03	0.01
SCC (x 10^3 mL^{-1})	166.3	162.3	162.7	33.4	1.00
MUN (mg N dL^{-1})	17.7	18.6	19.1	0.50	0.14
LW Before (kg)	376	363	373	9.96	0.64
LW After (kg)	412	396	412	10.8	0.49
LW change (kg)	+ 36.5	+ 33.3	+ 39.2	2.85	0.36
BCS Before	2.4	2.3	2.3	0.08	0.41
BCS After	2.6	2.5	2.5	0.10	0.68
BCS change	+ 0.2	+ 0.2	+ 0.2	0.06	0.90
AM Refusal (%)	3.4	3.1	9.2	2.28	0.12
PM Refusal (%)	6.0	5.4	11.2	2.63	0.24
Daily Refusal (%)	4.7	4.3	10.2	2.43	0.17

[1] FCM – fat corrected milk; SCC – somatic cell count; MUN – milk urea nitrogen; LW – live body weight; BCS – body condition score; AM – morning; PM – afternoon
[2] PKE – palm kernel expeller
[3] Control – concentrate containing 0 % PKE; Low PKE – concentrate containing 20 % PKE; High PKE – concentrate containing 40 % PKE
[4] SEM – standard error of mean
[a, b] Means in the same row with different superscripts differ ($p < 0.05$)

The daily concentrate refusals did not differ (p > 0.05) between treatments, even though a tendency can be seen. This is because the treatment groups had a high level of variation resulting in high standard error means. There are two potential reasons for the refusals of the concentrates. Firstly, the concentrates were fed in a meal form where the cows are used to pelleted concentrates, secondly, due to the inclusion of the lower palatable PKE. Milk yield was sustained in the low and high PKE treatment groups, regardless of the concentrate refusals.

Economic Evaluation

The net daily and monthly profit of each treatment concentrate was compared to each other as represented in Table 5.

Table 5: Milk price according to milk composition, feed price, and pasture price for three concentrate treatments with different palm kernel expeller inclusions

Parameter	Treatment		
	Control	Low PKE	High PKE
Milk Yield (kg cow^{-1} day^{-1})	21.3	21.3	21.3
Milk Price (R L^{-1})	R 3.74	R 3.74	R 3.74
Milk Income (R cow^{-1} day^{-1})	R 79.66	R 79.66	R 79.66
Milk Income (R $herd^{-1}$ day^{-1})	R 22 305.36	R 22 305.36	R 22 305.36
Decrease in daily income (R $herd^{-1}$ day^{-1})	R 0.00	R 0.00	R 0.00
Maize price (R ton^{-1})	R 2 580.00	R 2 580.00	R 2 580.00
PKE price (R ton^{-1})	R 0.00	R 2 225.00	R 2 225.00
Soybean Oilcake Price (R ton^{-1})	R 4 400.00	R 4 400.00	R 4 400.00
Maize price : PKE price	0.00	1.16	1.16
Feed Price (R ton^{-1})	R 3 449.00	R 3 277.00	R 3 100.00
Feed Price (R cow^{-1} day^{-1})	R 20.69	R 19.66	R 18.60
Feed Price (R $herd^{-1}$ day^{-1})	R 5 794.32	R 5 505.36	R 5 208.00
Decrease in daily input cost (R $herd^{-1}$ day^{-1})	R 0.00	R 288.96	R 586.32
Pasture Price (R kg^{-1})	R 1.00	R 1.00	R 1.00
Pasture Price (R cow^{-1} day^{-1})	R 9.00	R 9.00	R 9.00
Pasture Price (R $herd^{-1}$ day^{-1})	R 2 520.00	R 2 520.00	R 2 520.00
Decrease in daily input cost (R $herd^{-1}$ day^{-1})	R 0.00	R 0.00	R 0.00
Margin over feed cost (R $herd^{-1}$ day^{-1})	R 0.00	R 288.96	R 586.32
Margin over feed cost (R $herd^{-1}$ $month^{-1}$)	R 0.00	R 8 813.28	R 17 882.76

[1] MUN – milk urea nitrogen; SCC – somatic cell count; Herd – 280 cows; R – South African Rand
[2] PKE – palm kernel expeller
[3] Control – concentrate containing 0 % PKE; Low PKE – concentrate containing 20 % PKE; High PKE – concentrate containing 40 % PKE

The net daily and monthly profit only represents the income over feed cost and does not take any labour, machinery or any other farm related costs into account. Feed price was the only variable between treatments; all other factors were assumed similar and would not influence the economic analysis. The herd size for the calculations consisted of 280 cows in milk, which is the average number of cows per producer in the Western Cape. Milk price is based on milk composition (milk fat %, milk protein %, and SCC). As there were no differences ($p > 0.05$) observed between the milk yield or the milk compositions of the three treatment groups, the milk yield and milk price obtained for the control treatment group (21.3 kg cow^{-1} day^{-1}, R 3.74) was used over all three treatment groups. The average PKE price from January 2012 to September 2012 was obtained from Pieter Brönn (Intelact (Pty) Ltd, Eastern Cape), the average feed price from January 2012 to September 2012 was obtained from NOVA feeds, the milk price was obtained from Nestlé in September 2012, and the pasture price was obtained from Outeniqua Research Farm in September 2012. The PKE price included a transport fee of R 250 ton^{-1} in bulk from Port Elizabeth (Eastern Cape) to George (Western Cape).

The high PKE treatment group resulted in the highest net profit margin over feed cost, followed by the low PKE treatment group, at a maize to PKE price ratio of 1.16. The possibility of replacing maize with PKE and the savings associated with the change is subject to maize and PKE price. For the net profit margin in both the low and high PKE treatment groups to breakeven, the maize to PKE price ratio should be 1.28 and 1.47, respectively.

Conclusion

Replacing 16 – 30 % of maize with PKE in lactating dairy cow concentrates did not affect milk yield, milk fat percentage, milk protein percentage, SCC, LW, or BCS. Rumen fermentation was unaffected and a healthy rumen environment was sustained. The replacement of higher cost maize and soybean oilcake by a lower cost PKE decreased feed cost. It is however not recommended to include PKE at 40 % in the concentrate due to the increased time spent by cows in the milking parlour and the low palatability of PKE, which could lead to the tendency of increased concentrate refusals. It can be extrapolated from the data obtained from this study that PKE can be fed to cows on pasture at 2.4 kg cow^{-1} day^{-1}, while reducing the concentrate fed in the milking parlour (6 kg) by 2.4 kg cow^{-1} day^{-1}.

References

Abdullah, N. & Hutagalung, R.I., 1988. Rumen fermentation, urease activity and performance of cattle given palm kernel cake-based diet. Anim. Feed Sci. Tech. 20, 79-86.

Alimon, A.R., 2004. The nutritive value of palm kernel cake for animal feed. Palm Oil Developments 40. Malaysian Palm Oil Board. pp12-14.

Bargo, F., Muller, L.D., Kolver, E.S. & Delahoy, J.E., 2003. Invited review: Production and digestion of supplemented dairy cows on pasture. J. Dairy Sci. 86, 1-42.

Botha, P.R., 2002. Die gebruik van vogspanningmeters vir besproeiingskedulering by weidings. Weidingskursus Inligtingsbundel, 2002. Suid-Kaap

Landbou-ontwikkelingsentrum, Departement Landbou Wes-Kaap. pp 141-149.

Carvalho, L.P.F., Cabritta, A.R.J., Dewhurst, R.J., Vicente, T.E.J., Lopes, Z.M.C. & Fonseca, A.J.M., 2006. Evaluation of palm kernel meal and corn distillers grains in corn silage-based diets for lactating dairy cows. J. Dairy Sci. 89, 2705-2715.

Chanjula, P., Siriwathananukul, Y. & Lawpetchara, A., 2011. Effect of feeding rubber seed kernel and palm kernel cake in combination on nutrient utilization, rumen fermentation characteristics, and microbial populations in goats fed on Briachiaria humidicola hay-based diets. Asian-Aust. J. Anim. Sci. 24, 73-81.

Coetzee, K., 2012. Lacto Data Vol. 15 No. 1, May 2012 for Milk SA. Milk Producer's Organisation, koos.coetzee@mpo.co.za.

Delahoy, J.E., Muller, L.D., Bargo, F., Cassidy, T.W. & Holden, L.A., 2003. Supplemental carbohydrate sources for lactating dairy cows on pasture. J. Dairy Sci. 86, 906-915.

Garnsworthy, P.C., 1990. Feeding calcium salts of fatty acids in high-starch or high-fibre compound supplements to lactating cows at grass. Anim. Prod. 51, 441-447.

Lingnau, W.A.L., Meeske, R. & Cruywagen, C.W., 2010. High fibre concentrate supplementation for Jersey cows on kikuyu/ryegrass pasture system. Proceedings of the annual information day at Outeniqua research farm. 19 October 2010. pp. 53-60.

Meeske, R., Cronje, P.C. & Van der Merwe, G.D., 2009. High fibre concentrates for Jersey cows grazing kikuyu/ryegrass pasture. Proceedings of the annual information day at Outeniqua research farm. 6 October 2009. pp. 40-42.

Meeske, R., Rothauge, A., Van der Merwe, G.D. & Greyling, J.F., 2006. The effect of concentrate supplementation on the productivity of grazing Jersey cows on a pasture based system. S. Afr. J. Anim. Sci. 36, 105-110.

Meijs, J.A.C., 1986. Concentrate supplementation of grazing dairy cows. 2. Effect of concentrate composition on herbage intake and milk production. Grass Forage Sci., 41, 229-235.

Muller, L.D., Delahoy, J. & Bargo, F., 2001. Supplementation of lactating cows on pasture. Pennsylvania State University. http://www.das.psu.edu/research-extension/dairy/nutrition/pdf/supplementation-of-lactating-cows.pdf.

O'Mara, F.P., Mulligan, F.J., Cronin, E.J., Rath, M. & Caffrey, P.J., 1999. The nutritive value of palm kernel meal measured in vivo and using rumen fluid and enzymatic techniques. Livestock Prod. Sci. 60, 305-316.

Ranathunga, S.D., Kalscheur, K.F., Hippen, A.R. & Schingoethe, D.J., 2010. Replacement of starch from corn with nonforage fibre from distillers grains and soyhulls in diets of lactating dairy cows. J. Dairy Sci. 93, 1086-1097.

Samuels, M.L., 1989. Statistics for the life sciences. Collier MacMillan Publishers, London.

Sayers, H.J., 1999. The effect of sward characteristics and level and type of supplement on grazing behaviour, herbage intake and performance of lactating dairy cows. Ph.D. Thesis. Queen's University of Belfast. The Agricultural Research Institute of Northern Ireland. Hillsborough.

Soil Classification Working Group, 1991. Soil classification. A taxonomic system for South Africa. Memoirs of natural agricultural resources of South Africa, No 15. Department of Agricultural Development, Pretoria.

Varga, G.A., Dann, H.M. & Ishler V.A., 1998. The use of fibre concentrations for ration formulation. J. Dairy Sci. 81, 3063-3074.

Zahari, M.W. & Alimon, A.R., 2003. Use of palm kernel cake and oil palm by-products in compound feed. Palm oil developments 40. Malaysian Palm Oil Board. pp 5-9.

VERHOOG WINS DEUR MINDER VERVANGINGSVERSE GROOT TE MAAK!

R Meeske[1]

[1]Wes-Kaapse Departement van Landbou, Outeniqua Navorsingsplaas, George.

Agtergrond

Die koste om ’n Jersey vervangingsvers groot te maak varieer van R5500 to R7500 afhangend van die stelsel wat op die plaas gevolg word. Die getal vervangingsverse wat benodig word om die kudde in stand te hou word bepaal deur hoe lank ’n koei in die kudde bly. Indien koeie gemiddeld vyf laktasies in die kudde bly, is 20% vervanging nodig om koeigetalle te handhaaf. In ’n kudde van 400 koeie sal 80 vervangingsverse per jaar nodig wees. Indien alle koeie met suiwel semen geinsemineer word sal daar na verwagting 200 verse per jaar gebore word. Met ‘n 5% mortaliteit sal 190 vervangingsverse per jaar beskikbaar wees. Onder omstandighede waar geen verdere kuddegroei moontlik is nie, sal ongeveer 100 verse per jaar verkoop moet word. Wanneer die prys vir vervangingsverse hoër is as wat dit kos om ’n vervangings vers groot te maak, word boerdery inkomste verhoog.

Indien die verkoopprys van ’n vervangingsvers naastenby dieselfde is as wat dit kos om haar groot te maak, moet daar besin word oor die getal vervangingsverse wat grootgemaak moet word.

Maak minimum vervangingsverse groot.

Selekteer die boonste helfte van die koeie op grond van teelwaarde en melkproduksie en insemineer met suiwel semen. Koeie met laer teelwaardes en laer melkproduksie word met vleisbees semen geinsemineer. Wanneer die kruiskalwers gebore word, word hulle so gou moontlik na geboorte verkoop (1 tot 2 weke ouderdom). Die prys waarteen kruiskalwers verkoop word hang af van die aanvraag en die prys wissel van R400 tot R1000 per kalf. Kalf mortaliteite moet so laag as moonlik gehou word en moet nie 5% oorskry nie.

In Tabel 1 word die invloed van die besluit om die onderste helfte van die koeie in die kudde met vleisbees semen te insemineer op vee getalle en ruvoer behoefte aangedui.

Die oppervlakte benodig vir grootmaak van verse kan met 21 ha verklein word wat meer weiding vir melkbeeste beskikbaar stel.

Tabel 1. Die invloed van KI van onderste helfte van koeie in kudde gebaseer op teelwaarde en melkproduksie met vleisbees semen op getal diere en ruvoerbehoefte.

	Kudde 1: **Alle koeie suiwel**	**Kudde 2:** **Helfte koeie suiwel**
Getal koeie in kudde	400	400
Verse 0-12 maande	190	95
Verse 12-24 maande	180	90
Totaal	770	585
Kruiskalwers	0	200
Ruvoer verse 0-12m (3kg)	208050	104025
Ruvoer verse 12-24m (6.5kg)	427050	213525
Totaal kg/jaar ruvoer verse	635100	317550
Verskil kg ruvoer/jaar		317550
Ruvoer vir koeie (kg/jaar)	1460000	1460000
Ha benodig koeie (15 t/ha)	97	97
Ha benodig verse 12-24m	13.9	6.9
Ha benodig verse 0-12m	28.5	14.2
Ha Totaal	139.4	118.1

Genetiese vordering

Die genetiese vordering in die kudde behoort te versnel indien net koeie met bogemiddelde teelwaarde gebruik word om vervangingsverse uit te teel. Die teelwaardes van die boonste en onderste helfte in die kudde op Outeniqua is +310kg en +55 kg melk, +9 kg en + 3 kg bottervet en +8 kg en +2kg respektiewelik. Die besluit om 'n koei as vers-moeder in die kudde te selekteer moet op grond van teelwaarde, melkproduksie, tipe en uier gedoen word. Maak gebruik van rekords, indekse en kundiges om die top helfte van koeie in die kudde te identifiseer. Verse kan kan op grond van voorspelde teelwaardes geselekteer word. Indien 100 verse per jaar kalf sal 80 moet deurgaan na tweede laktasie.

Ruvoer voorsiening

Ruvoer produksie op die plaas is die eerste faktor wat die getal koeie in die kudde beperk. Deur die getal vervangingsverse wat per jaar grootgemaak word te verminder, behoort meer ruvoer vir melkkoeie beskikbaar te wees. 'n Jersey vers sal 3.4 ton DM ruvoer/weiding inneem tot op 24 maande ouderdom. Indien die getal verse wat per jaar grootgemaak word verminder met 100, sal ruvoer behoefte per jaar met 340 ton DM verlaag. Indien voldoende ruvoer op die plaas beskikbaar was om al die verse groot te maak sal 340 ton ruvoer beskikbaar wees om meer koeie te melk. 'n Jerseykoei benodig ongeveer 10kg DM weiding per dag en gevolglik kan 93 meer koeie gemelk word. Indien die marge bo gespesifiseerde koste per koei per jaar R4000 is, sal die marge bo gespesifiseerde koste styg met R372 000 per jaar. Uit die verkoop van kruiskalwes behoort 'n additionele inkomste van R40 000 te realiseer (100 kalwers X R400). Dit beteken dat die "wins" per dragtige vers wat verkoop word wanneer alle koeie met suiwel semen geinsemineer word ongeveer R4120 moet wees om gelyk te breek met wanneer die onderste helfte van koeie met vleisbees semen geinsemineer word en meer koeie gemelk word. Indien die koste om 'n vervangingsvers tot op punt van kalf groot te maak R6000 is , en verse word teen R7500 verkoop is die wins net R1500 per vers. Die opsie om minder vervangingsverse groot te maak sal in die geval winsgewendheid van die melkkudde aansienlik verhoog (R200000 tot R260000 per jaar op 'n 400 koei kudde)

In gevalle waar daar reeds 'n ruvoer/weiding tekort was en 340 ton lusernhooi aangekoop was, word uitgawes met tot R612 000 verlaag afhangende van die prys van lusernhooi (R1800/ton).

Gevolgtrekkings

Die besluit om net verse te teel uit die boonste helfte van koeie in die kudde en vleisbees semen op die onderste helfte van koeie te gebruik in kuddes wat nie verder kan uitbrei nie kan winsgewend wees. Die behoefte om ruvoer aan te koop word verlaag. Produsente moet seker maak dat hul versgrootmaak praktyke optimaal is en dat vers mortaliteite nie meer as 5% is nie om te verseker dat voldoende vervangingsverse beskikbaar is.