

Foggage value of sub-tropical grasses

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Submitted in partial fulfilment of the requirements of the degree

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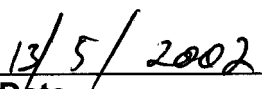


Declaration of dissertation

I declare that this thesis, which I hereby submit for the degree M.Sc. (Agric.) – Pasture Science at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at another university.



N.C.M. Engelbrecht



Date

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Abstract

Foggage value of sub-tropical grasses

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The use of foggage as winter feed for animal maintenance is unlikely to totally replace hay and/or silage, but should be used as an alternative for the early winter. The most important objective in producing foggage is to feed animals to at least maintain body weight through the winter season. As foggage is generally not a high quality feed, it usually can not be used for producing animals without supplementation. Using foggage can also minimise expensive inputs, such as labour and machinery. This is the single most outstanding advantage of using pasture foggage over hay, haylage, crop residues or silage. Although pastures also have establishment and fertiliser costs, these are less than costs associated with intensive annual crops. Many pastures are

also perennial, which means less establishment costs. This emphasises the importance for less intensive farming systems.

Depending on what the objectives of the farmer are, he can manage foggage to produce a high yield with a lower quality or *vice versa*. Thus it is critical to maintain a balance between yield and quality. Foggage quality was inversely related to the growing season after the pasture was closed-up and thus the quality will be lower with earlier closing-up time. Fertilisation, especially with nitrogen, will increase the nutritive value of the product (6% - 12%CP).

The aim of this study was to determine which pasture provides the best foggage in different scenarios. The conclusion is, therefore, that a farmer must first decide on his management plan and where his foggage will fit in. Then it is recommended to choose the species (or accession) that is best adapted to his specific area of farming. Silk sorghum and Coastcross II had the best yields recorded. Smutsfinger grass was very palatable, had high digestibility and would, therefore, be recommended for quality in the higher rainfall eastern parts of the country. Because of their drought resistance, Molopo and Kleingrass will be recommended for the warmer areas with less rainfall and Molopo especially for small farmers who lack overall grazing management skills or infrastructure.

Uittreksel

Die waarde van sub-tropiese grasse as staande hooi

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Die gebruik van staande hooi om wintervoer te produseer vir die onderhoudsbehoefte van vee sal onwaarskynlik hooi en/of kuilvoer totaal kan vervang, maar moet gebruik word as 'n alternatief in die vroeë winter. Die mees belangrikste doelwit van staande hooi produksie is om ten minste die dier se liggaamsmassa te behou gedurende die winter seisoen. Omdat staande hooi beskou word as 'n lae kwaliteit voer, kan dit nie vir produserende vee gevoer word sonder addisionele nutriënt suplementasie nie. Deur gebruik te maak van staande hooi kan duur insetkoste soos arbeid en masjinerie beperk word. Dit plaas staande hooi bo hooi, graskuilvoer, oesreste en mieliekuilvoer. Alhoewel weidings ook vestigings- en bemestingkoste het, is dit aansienlik laer as sodanige koste van intensiewe

eenjarige gewasse. Die meeste aangeplante weidings is meerjarig en dit beteken laer vestigingskoste. Dit beklemtoon die belangrikheid van minder intensiewe boerderysisteme.

Afhangend van wat die boer se doelwitte is, kan hy die staande hooi so bestuur om 'n hoë opbrengs met 'n laer kwaliteit te produseer of andersom. Dit is dus uiters krities om 'n balans te handhaaf tussen opbrengs en kwaliteit. Die kwaliteit van die staande hooi hou indirek verband met die groeiseisoen nadat die weidings onbewei gelaat is. Die kwaliteit sal dus laer wees met 'n vroeër onttrekking van beweiding. Die voedingswaarde van die produk word deur bemesting verbeter, veral indien stikstof gebruik word (6% - 12% RP).

Die doel van die studie was om die beste weidingsgewas te evalueer vir die maak van staande hooi indien dit vergelyk word onder verskillende omstandighede. Die boer sal dus moet besluit op 'n spesifieke bestuursplan en hoe staande hooi suksesvol daarby gaan inpas. Daarna sal die wei-spesie (of seleksie) wat die beste aangepas is in die omgewing, aanbeveel word. Silk sorghum en Coastcross II het die hoogste opbrengste gelewer in hierdie studie. Smutsvingergras is baie smaaklik, het 'n hoë verteerbaarheid en kan dus aanbeveel word vir produksie van kwaliteit materiaal in die oostelike hoë reënval dele van die land. Molopo en Kleinbuffelsgras kan aanbeveel word vir die warmer dele met 'n laer reënval as gevolg van goeie droogteverdraagsaamheid – Molopo word ook aanbeveel vir kleinboere met min weidingsbestuurservaring of infrastruktuur.

Chapter 1

Prepared according to the guidelines of the African Journal of Range & Forage Science

Introduction Chapter – Literature Review

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Abstract

Foggage is an alternative winter feed for livestock in the dormant season. The ever increasing input costs drives the modern farmer to seek a cost effective winter feed such as foggage, which may be produced on marginal soils. It is fed to animals as a standing hay thereby reducing labour and mechanical costs. The quantity and quality of foggage is determined not only by climatic conditions, but also by management which also includes closing-up time as a very important component. With the correct fertilisation practice, especially nitrogen, the value of the foggage material can be improved in terms of both yield and quality (6% - 12%CP). Foggage deserves a permanent place in feed-flow programmes, (summer rainfall areas, in dryland conditions) because of its dependability, low inputs and practical advantages.

Additional index words: Crude protein, foggage, grass, maintenance feed, marginal soils, pasture, standing hay, winter feed.

Introduction

One of the biggest problems confronting the modern farmer, is the ever increasing input costs and the weakening of the overall economy. The agricultural economy especially is struggling because of declining margins between input costs and product prices.

This emphasizes the importance for less intensive farming systems. Most of the soils used for crop production in South Africa, are classified as marginal. As these marginal soils are still commercially farmed erosion is aggravated by excessive tillage to produce poor crop yields and quality. The crops used are often totally unsuited to such soils. Although the use of pastures on marginal soils is not a new concept, they offer farmers, who seek stable alternatives to risky crop production, a viable alternative.

Although pastures also have establishment and fertiliser costs, these are less than costs associated with intensive annual crops. Many pastures are also perennial, which means establishment costs, which are the biggest initial input cost, can be spread over several years. Expensive inputs, such as labour and machinery, can also be minimized by using foggage. This is the single most outstanding advantage of using pasture foggage over hay, haylage, crop residues or silage. This potential of foggage to produce winter feed for animal maintenance is unlikely to totally replace hay and/or silage, but should be used as an alternative for the early winter (Brockett 1983).

The term foggage is used to describe forage which accumulates, or is stockpiled, during the growing season for use in the dormant season. Selected grass species, which are adapted for such use, may then be grazed by livestock during the dormant season to minimize labour and mechanical

costs (Dickinson *et al* 1990). This will enable farmers to stabilise their production systems.

Description of foggage

In this study we prefer to use the term foggage, although there are other terms also in use. These includes standing hay, stock-piled pasture, autumn-saved pasture, autumn-accumulated pasture and fall-saved pasture (Tainton 2000), but the description of this production system stays essentially the same and was already noted by writers in the 18th and 19th centuries (Lloyd and Turnor, 1794, Hassall, 1794, Elliot, 1898). The term foggage was derived from the Welsh “fog, by which is understood the summer’s grass preserved until the following spring and sacrificing the crop of hay” (Hughes 1955). At first it was known as a somewhat loose term for grass preserved in this fashion, but later it was used extensively for conserving grass on the land. Some authors made a distinct difference between the terms foggage and “rouen”, where the latter meant the second growth of grass after mowing the hay in summer and protecting it from livestock until the spring months (Davies 1815).

Pastures preserved in such a way should not be confused with herbage that is accumulated during the normal operation of a rotational grazing system. The herbage produced in the first part of the early summer, should rather be conserved as hay or silage for use in the second half of winter. The two most important factors affecting the success of foggage systems are the quality and quantity produced. These are related to the closing-up time, choice of species and management before closing-up including fertilisation (Brockett 1983).

Grass species adapted and used for foggage

Species that are to be used for the production of foggage, have to fulfill certain criteria. These includes yield, leaf to stem ratio and the quality in terms of crude protein (% CP). The latter should be no less than 7% CP for large farm animals and 6% CP for small farm animals (Dickinson *et al.* 1990). Thus the performance of animals is also a valuable criterion in evaluating grass species for use as foggage.

Traditionally used species

In addition to the foggage value of the particular species, it's also important to consider such factors as climate, soil type, aspect and other uses. Species may be divided into three categories:

Summer grasses, which typically are nutritious and palatable year-round and are often preferred species because of the relative high feeding value during winter, although they are already dormant. They also fulfill the criteria for the provision of foggage (local climate, soils and livestock production systems). These include kikuyu (*Pennisetum clandestinum*), Smutsfinger grass (*Digitaria eriantha*), Guinea grass (*Panicum maximum*), Blue Buffalo grass / Foxtail Buffalo grass / Buffelgrass (*Cenchrus ciliaris*), Star grass (*Cynodon nlemfuensis*), Coastcross II (*Cynodon* hybrid), Dallis grass (*Paspalum dilatatum*), Rhodes grass (*Chloris gayana*) and Nile grass (*Acroceras macrum*) (Rethman 1983, Dickinson *et al.* 1990 & Tainton 2000).

Summer grasses, which lose their quality in the winter, are not suitable for foggage. Weeping lovegrass (*Eragrostis curvula*) is one such species. With the use of effective fertiliser management, however, the yield and high crude protein content can be improved (Dickinson *et al.* 1990). *Eragrostis curvula*

could, therefore, be used for foggage in areas where it is better adapted to climatic conditions than other summer or temperate species.

Temperate, or cool season, grasses are those which grow in spring, autumn and winter. Although these species have the potential to provide foggage, they are not managed the same as summer species. They are only closed-up in autumn, otherwise they would not have the high quality expected of such species. The temperate species include Tall fescue (*Festuca arundinacea*), Cocksfoot (*Dactylis glomerata*), annual ryegrass (*Lolium multiflorum*) and perennial ryegrass (*Lolium perenne*). Use of the latter two should be within 3 months, as the quality of the adult leaves declines rapidly (Tainton 2000). Rethman (1983) noted that the use of temperate species for foggage can be recommended where moisture is not limiting. Moisture is, however, often a limiting factor on the Eastern Highveld and in Northern Natal. Although legumes are often grown in association with these type of grasses, they often do not fulfill the criteria for good quality foggage as they lose their leaves in winter (Brockett 1983). Thus the summer species perform best under relatively dry conditions and the temperate / cool season species under wetter conditions. All factors must be taken in consideration in choosing the correct species along with the correct management procedures.

Management of Foggage

Management will always be a major factor determining the success of a production system. To make a foggage-system work, it is necessary to produce a product of good quality in the most economical way. Quality and

quantity are the two most important aspects of foggage production. To ensure high quality and quantity, the time of closing-up and fertilisation are very important.

Closing-up time

The terms “closing-up time” and “put-up time” are interchangeable and both are used extensively. At close-up, all the plant material is removed prior to permitting regrowth without any disturbance. This is done by either mowing the pasture or by grazing it down to remove all the herbage (Cooper & Morris 1973). This ensures the growth of material of the same age and maturity throughout the pasture.

Under local climatic conditions, with the grass species evaluated thus far, it would appear that the best time to close the pasture up is between early January and early March. This withdrawal period has a strong influence on the quality and quantity of the foggage (Tainton 2000).

Quantity of foggage

Depending on what the objectives of the farmer are, foggage can be managed to produce a high yield with a lower quality or *vice versa*. The earlier the foggage is closed up, the higher the production of dry matter yield would be. But this high yield often leads to the production of less palatable mature material, that won't be readily consumed by the animals. Conversely, if the foggage is closed up too late in the growing season, too little material is then produced. Thus, to produce a reasonable amount of herbage, with a relatively good quality (more leaves than stems), pastures should be closed-up between January and March in the summer rainfall areas of the southern hemisphere (Brockett 1983).

This balance between the yield and quality is strongly influenced by the year to year rainfall variability and must be managed to accommodate such variability. The quality required also depends on the type of animal utilizing the foggage. Cattle need a more coarse herbage type in comparison with sheep. For sheep, therefore, the closing-up date would be later than for cattle to produce a lower yield but with younger more leafy material. The type of grass species used, determines the potential growth of the plant after the closing-up. This together with the amount of fertiliser applied, will determine the yield and quality of the foggage. These variables can be manipulated to provide different classes of animals with the preferred feeding material (Tainton 2000).

Table 1 Foggage yields (t DM/ha) of different pastures in three areas of Natal.

The pastures were closed-up in either January or February (Brockett 1983).

Species	Bioclimatic Area					
	Midlands		Berg Area		East Griqualand	
	1 Jan.	1Feb.	1 Jan.	1 Feb.	1 Jan.	1 Feb.
Kikuyu or Smutsfinger	6.0	4.2	5.5	3.9	4.5	3.2
Nilegrass	4.0	2.8	3.3	2.3	2.8	1.9
Cocksfoot or Tall Fescue	3.5	2.5	5.0	3.5	2.5	1.8

Foggage quality

As with yield, the quality is strongly influenced by the closing-up time. Tainton (2000) reported that foggage quality was inversely related to the growing season after the pasture was closed-up. As mentioned in the previous paragraph, quality will be lower with earlier closing-up time.

The crude protein (CP) content is often used as the measurement of foggage quality, but is not always a very reliable measure. The relative livestock performance data on the different grass species has also been used. This reflects the acceptability of the grass for the animals (Rethman 1983). Brockett (1983) explained that young, growing animals would need a pasture of higher quality than older animals, which often only require maintenance during winter. Thus, to produce high quality material for producing animals, it may be necessary to close late and sacrifice yield.

Although *Eragrostis curvula* has a CP value of 4% to 6% in the winter (Barnes 1968; Nel 1964; Rethman 1973), CP may be increased by chemical treatment in late summer/early autumn with a herbicide such as paraquat (1,1' dimethyl-4, 4' dipyridylum dichloride). Such dessicants are applied to standing herbage (in autumn) to artificially cure the material and so retain most of the nutritional value. Such strategies not only improve the CP levels, but also the digestibility, with only a slight reduction in dry material (DM) yields (Brockett 1977).

Fertilisation of foggage

The correct application of fertiliser will also affect both quality and yield of the foggage. Nitrogen (N) is by far the most important nutrient in this respect and can be used to produce a foggage with CP values of 6% - 12%. The other

nutrients of importance are phosphorus (P) and potassium (K), which are required to ensure a good response to N. A soil analysis is necessary to determine whether P and K are deficient. Such nutrients should only be applied when soils are deficient in these elements.

It was found by Rethman (1983) that the effect of nitrogen was strongly influenced by the time of application. The closer to closing-up time the N-fertilisation was given, the better the crude protein content of the material and the yield response. Marked increases in the yield, due to nitrogen application, may, however, depress the feeding value of the foggage. This is because the higher the yield of foggage, the higher the undesirable cell wall components. The quantity and quality of the foggage are, therefore, substantially influenced by the level and timing of the nitrogen fertilisation.

Table 2 Reaction of kikuyu foggage to N- applications. Average of two seasons (Rethman 1983).

kg N/ha Applied in Jan.	% CP in July	Dry Material ton/ha July	CP kg/ha
0	6.3	3.2	202
50	7.0	10.1	707
100	8.7	11.7	1018

As with all the other factors affecting the fertiliser efficiency, the specific species used also influences the amount of N applied and the growth potential after closing-up. It has been reported by Corbett (1957) that the influence of N

fertiliser applied in the late summer/autumn on the quality of foggage, produced some uncertainty. Cold resistance is a species dependent trait and young herbage is more resistant to cold. The application of nitrogen fertiliser also increases the plant's resistance to low temperatures (Brockett 1977).

Utilisation of Foggage

The most important objective in producing foggage, is to feed animals to at least maintain body weight through the winter season. As foggage is generally not a high quality feed, it usually can not be used for producing animals without supplementation (Rethman & De Witt 1991).

It is often necessary to make provision for an adaptation period. This often results in an initial decline in body weight as the intake of such material may be low for a period of time. After this adaptation period intake improves but utilisation can result in trampling and waste. It is, therefore, often recommended that grazing management be based on high utilization grazing (HUG) (Corbett 1957). This can be done using rotational grazing or continuous grazing. With strip grazing (rotational grazing), an electric fence is often used to limit the forage available and thereby force animals to consume the material. Animals first use the better material with continuous grazing, but performance declines when the residual material is used (Meaker & Coetsee 1978). With creep grazing, the calves or lambs are given the opportunity to select a better quality feed to improve performance (Tainton 2000). A supplementary protein can be supplied to adult animals when the nutritive value of foggage declines later in the winter season.

As animals always tend to consume the best quality material early in the winter their condition often declines at the end of winter and in early spring. This is due to the limited availability of new green material and the refusal or rejection of old frosted, soiled residues.

While quality of most species traditionally used as foggage is sufficient to maintain livemass without supplements or protein licks, temperate species such as tall fescue and perennial ryegrass can even maintain ewes and lambs through the autumn and winter with moderate weight gains, although it is not always the case (Lyle 1994).

Summary

Foggage can be used to produce a winter feed for animal maintenance on normally marginal soils. It is also a labour, mechanisation and production cost saver, but cannot totally replace the use of high quality green feed, hay and silage in livestock production systems. The quantity and quality are the two most important aspects of foggage production. The early closing-up of pastures produces a high yield and a lower quality, given favourable climatic conditions. With a later put-up date, however, the quality will increase while yield declines. Fertilisation, especially with nitrogen, will increase the nutritive value of the product (6% - 12%CP). With the use of additional supplementation or protein licks, the farmer can support productive animals on foggage throughout the dormant period.

In this study the value of foggage was determined using different high potential foggage pastures. These included Smutsfinger grass (*Digitaria eriantha*), Buffelgrass (*Cenchrus ciliaris* cv. Molopo), Coastcross II (KII)

(*Cynodon* hybrid), P66 Creeping fingergrass (*Digitaria eriantha* spp. *pentzii*), Kleingrass (*Panicum coloratum*), Guinea grass (*Panicum maximum* cv. Gatton), Silk sorghum (Sorghum hybrid) and Purple plume grass (*Bothriochloa bladii*).

The pastures were evaluated in terms of quantity (yield), quality (digestibility, protein content) and structure (leaf : stem). The Smutsfinger grass, Buffelgrass, Coastcross II and Silk sorghum were also grazed by sheep to find a correlation between the assumed values and actual values of grazing. The aim of this study was to determine which pasture yielded the best foggage in different scenario's.

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Chapter 2

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The foggage value of Silk Sorghum as influenced by age of pasture

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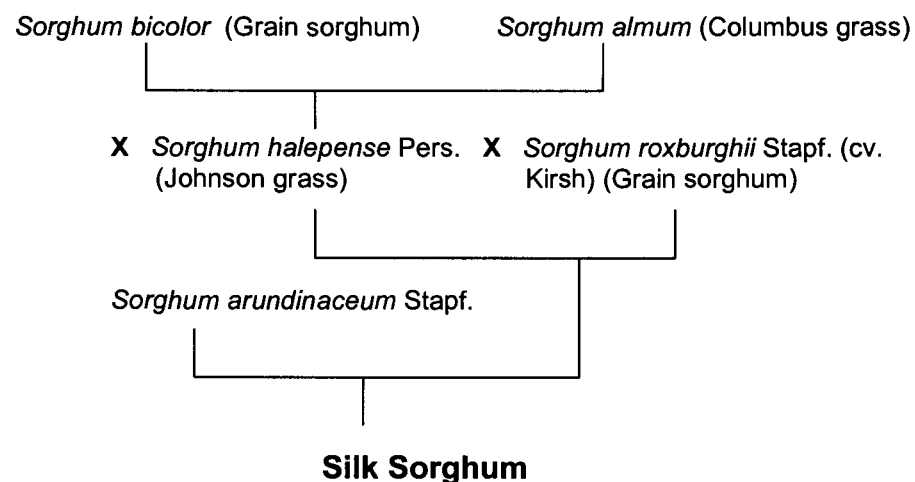
Abstract

The aim of this study was to evaluate the potential of Silk sorghum as foggage by comparing two different ages – one and two year old pastures. Silk is often described as a grass with a high quality in the first year after planting, but with increasing age, the quality declines and the production increases. Therefore, both quantity and quality of material were monitored from summer to winter. The yields registered in Pretoria demonstrated the potential of Silk to produce high yields of a good quality forage under dryland conditions. Older pastures produced more material than younger stands. This, however, resulted in a reduction in quality. The major trouble with Silk sorghum is the alleged infestation of other crops because of its close relationship with Johnsongrass.

Additional index words: Pastures, quantity, quality, standing hay, winter feed.

Introduction

Silk sorghum is a relatively new forage sorghum hybrid which was planted in the Potchefstroom area for the first time in 1984. This Australian bred perennial forage sorghum proved valuable in the 1980's drought, and is used widely as a foggage. It was originally developed by the Australian CSIRO in the 1970's. Dr. A.J. Pitchard registered the crop in January 1978. It was bred from different cultivars, which included Columbus grass, Johnson grass and certain grain sorghums (Le Roux 1989). The family tree of Silk sorghum includes:



Silk sorghum is planted mainly under dryland conditions in areas with an average annual rainfall of 400mm and more. Under more favourable circumstances it has the potential to flourish and produce yields of up to 13 ton/ha. This grass type establishes well on clay soils and some stands on the Springbok Flats are now as old as 17 years (Dannhauser 1991). Silk is an aggressively growing, tufted, perennial (3 – 4 years), which forms plumes that correspond with the morphology of Columbus grass (cv. Crooble) and Israeli sorghum (Lambert & Graham 1996). It reaches a maximum height of 3.5 m

under ideal growing conditions, but under dry land conditions, it stands between 1 to 1.5 m tall after ± 100 days. The plant produces short creeping underground rhizomes, but also regenerates readily from seed (Humphreys & Partridge 1995).

Silk is not particularly frost-tolerant, but comes away early in the spring with strong basal shoots and some secondary shoots from the aerial stems (O'Reilly & Cameron 1992). It takes relatively long to reach the flowering stage and, therefore, has the potential to produce more leaves than many other sorghums. The large seed make establishment easy, and provides feed a short time (Humphreys & Partridge 1995). The seed does not digest in the animals digestive system, and can, therefore, be distributed by livestock (Le Roux 1989). Silk was subsidized for conversion of marginal soils from annual crops to perennial pastures in South Africa and stimulated a lot of interest. Because of it's close relationship with other sorghums, Silk often causes infestations in them and is, therefore, often classified as a weed in Australia (Le Roux 1989).

Material and Methods

Site

Pure stands of Silk Sorghum were established on the Field Experimental Section of the Hatfield Experimental Farm of the University of Pretoria. The farm is situated 1353m above sea level, at 25° 45' South and 28° 16' East, in a summer rainfall area with a long term mean annual precipitation of 708 mm. The soil form is Hutton (MacVicar *et al.* 1997) with a weak structure and a

homogenous red colour and is non-calciferous. The soil can be described as a sand-clay-loam with a 20% – 35% clay content.

Layout

The objective of this trial was to compare two different ages of Silk sorghum, the first a one year old stand and the other a two year old stand.

Two blocks (each 35m x 200m) of Silk were established in February 1999. The next two blocks (35m x 200m) were planted in November 1999. The size of the pasture provided enough material to facilitate ample sampling to generate replication. All four the blocks were fertilized with a standard nitrogen (100kg N/ha) as the soil samples indicated that there were no shortages of either phosphorus (P) or potassium (K). The nitrogen were applied as one application in mid-summer.

Collection of data

Plant based observations

Pasture production or availability was determined:

- (a) in mid-summer, when the production in the first half of the growing season was determined by clipping six replicated quadrats (1m² each) in each paddock;
- (b) in autumn, when the standing crop in terms of DM yield and leaf / stem ratio's was determined on similar quadrats to describe the pasture prior to the commencement of winter grazing and
- (c) in winter, when the residue after winter grazing was assessed, in terms of yield and leaf / stem ratio's on six replicated quadrats in each paddock.

Pasture quality (of clipped samples) in terms of crude protein (CP) and *in vitro* digestibility (IVDOM), was determined for both leaf and stem components in summer, autumn and winter. CP was calculated ($\% \text{ N} \times 6.25$) after $\% \text{ N}$ was determined using the Kjeldahl technique (AOAC 1995), while *in vitro* digestibility of organic matter (OM) was determined using the technique of *in vitro* fermentation (Tilley & Terry 1963 as modified by Engels *et al.* 1981).

Animal based observations

The two pastures (one and two years old) which were stockpiled in the late summer were grazed (as foggage) from \pm 10 April 2000 to the beginning of August 2000. Grazing was by sheep stocked according to the availability of feed to ensure that comparable grazing pressures (amount of feed / animal unit) were applied on the different pastures. Sodium Hyposulfite ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) was added to the drinking water of these sheep to reduce possible prussic acid poisoning (a problem common to grazed sorghum) and a standard drenching and inoculation program to eliminate parasites or diseases as confounding factors was followed. No mineral, protein or energy supplementation was provided.

After a two week adaptation period (necessitated by the fact that the sheep had been on a milled, stall-fed ration prior to being placed in the experimental pastures) data was collected at regular intervals (25/4, 10/5, 23/5, 30/5, 14/6, 27/6, 12/7 and 1/8) to assess the variation in the quality of foggage over the winter grazing period. At each date two oesophageal fistulated sheep were used to obtain samples of material selected by the grazing animals. The following procedures were followed in the collection of these samples : the

fistulated sheep were placed in the designated paddock for \pm 2 hours together with other sheep, then fistula samples were collected, the excess moisture was squeezed out, the samples were then placed in bags to be freeze-dried and milled. These samples were then analysed for IVDOM using the procedures already described. At the same time as fistula samples were collected clipped samples (to simulate animal selection) were collected and analysed for comparative purposes.

Analysis of data

An analysis of variance with the Proc-GLM model (SAS 1996) was used to determine differences between treatments. Least square difference (LSD) were used and the level of significance was tested with the Bonferroni test (Samuels 1989).

All the below mentioned observations were done after an adaptation period of two weeks. The sheep typically refused most of the material for the first week, as they were used of being fed finer milled material in the past. The second week was a different story, as they got used to the structure of the material and became quite partial to the mature Silk.

Results and Discussion

Availability of forage

Previous studies have indicated that Silk often does not reach it's full potential in the first year (Humphreys & Partridge 1995). This was also evident in the results presented in Table 1 where the yields of 1-year-old and 2-year-old pastures are compared. Although the production of the older pasture was

higher it might possibly increase still further if left to grow for another year or two. This might, however, result in a further decrease in quality.

Table 1 The dry matter available (t DM/ha) on Silk pastures at different stages as affected by age of pasture.

Age	Season		
	Summer	Autumn	Winter
1 year	5.2 ^a	6.1 ^b	2.5 ^c
2 years	9.5 ^a	10.7 ^b	3.1 ^c

Values in rows with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

The production of Silk was significantly better on the older pastures in both the early and late growing season (83% and 75% higher yields respectively). Whilst the early growing season growth could be used for grazing, hay or silage – dependent on the needs of the farmer – the late season growth was utilised as foggage / standing hay in the winter. The efficiency of utilisation of this foggage was evidently well regulated by varying the stocking rate to ensure comparable grazing pressures being applied to the different pastures. This is well illustrated by the minimal differences in the residue remaining at the end of the winter grazing period.

% Leaf in available forage

Contrary to expectation (Literature Review) the younger pasture was less leafy than the older pasture in autumn (commencement of winter grazing)(see Table 2), while there was still a relatively high % leaf in the residue, indicating good utilization of both leaf and stem material in the winter grazing period.

Table 2 The % leaf (DM) of Silk sorghum at the start and end of the winter grazing period.

Age	Season	
	Autumn	Winter
1 year	33% ^a	47% ^y
2 years	62% ^b	42% ^y
Average	48% ^x	45% ^x

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Quality of available forage

The CP content of the Silk (see Table 3) was much better in summer than either autumn or winter when senescence, frost and utilisation affected quality. This decline in the CP content was less marked in the hand clipped 2-year-old pasture, where CP declined from 6.5% in summer / autumn to 6% at the end of the winter. In contrast the one-year-old pasture declined from 8.7% in summer / autumn to 4.9% at the end of winter. As expected, the leaves of both pastures had a higher CP content than the stems. The quality selected

i 15968562
b 15380634

by the sheep from the one-year-old pasture, remained high from summer / autumn (16.1 %) to winter (11.8 %). The quality selected by the sheep from the two-year-old pasture, also remained relatively high from summer / autumn (9.9 %) to winter (7.4 %).

Table 3 The percentage crude protein (% CP) of Silk at various stages

Age and structure	Summer	Late Autumn	Winter
1 year (Leaves)	17.3 % ^a	7.9 %	6.7 % ^c
2 year (Leaves)	10.3 % ^b	11.7 %	8.4 % ^c
1 year (Stems)	6.6 % ^c	2.8 %	3.1 % ^e
2 year (Stems)	1.2 % ^e	2.8 %	3.5 % ^e
1 year (Fistula)	15.4 % ^a	16.8 %	11.8 % ^b
2 year (Fistula)	8.0 % ^b	11.7 %	7.4 % ^c

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

The *in vitro* digestibility of Silk (see Figs. 1 and 2) declined from autumn to late winter with a bigger difference in the digestibility of stem material between the different pastures. The digestibility of the different components was, however nearly the same at the end of winter. Animals grazed the one-year-old pasture more readily at the beginning of the trial period, but by the end of winter there was very little difference between pastures.

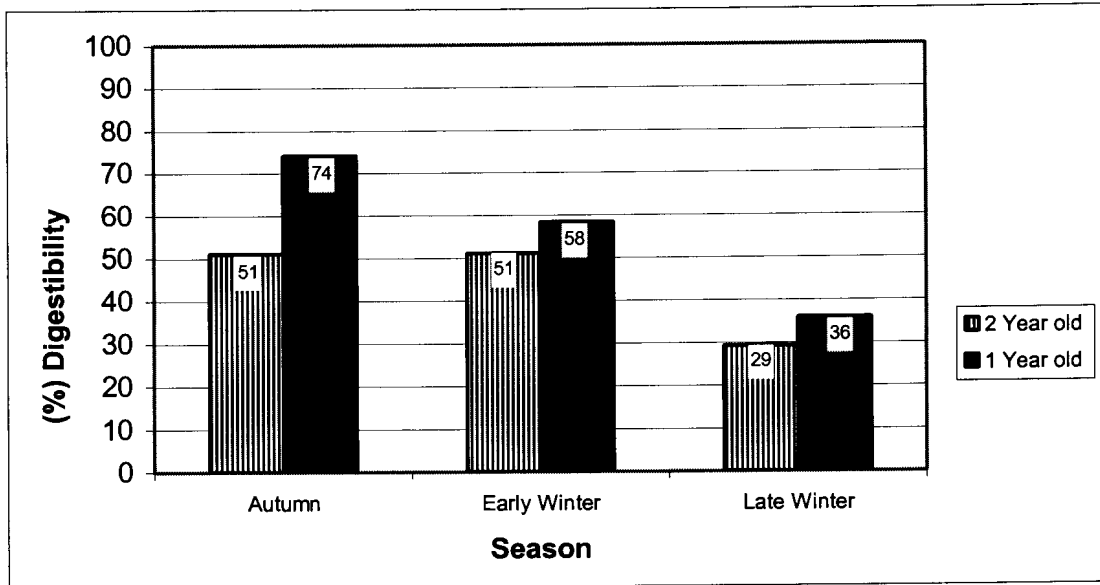


Figure 1 *In vitro* digestibility (%) of Silk sorghum leaves from clipped samples.

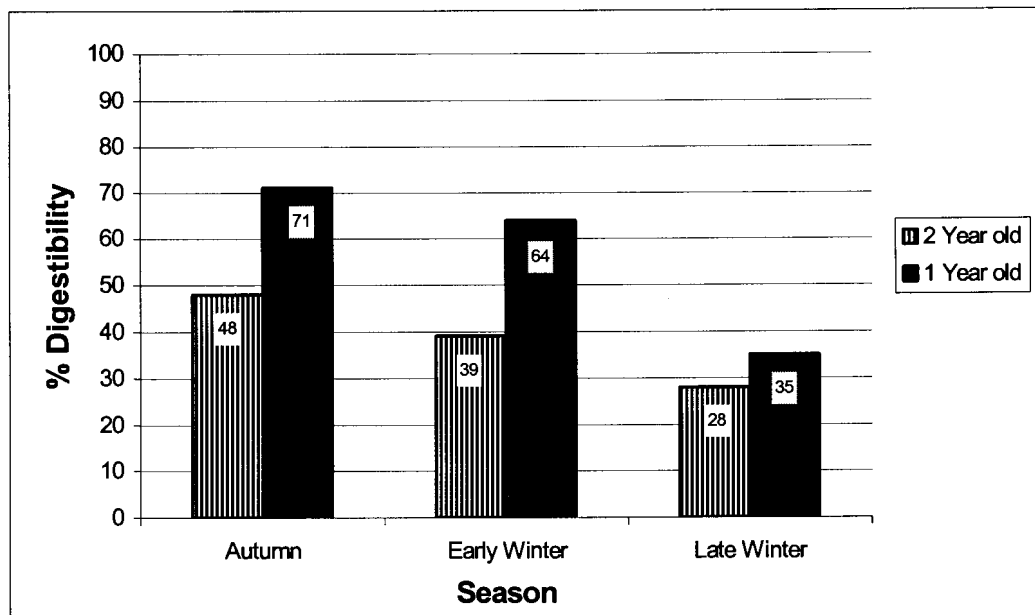


Figure 2 *In vitro* digestibility (%) of Silk sorghum stems from clipped samples.

It is also quite evident from Figures 3 and 4, which illustrate the *in vitro* digestibility of fistula samples (grazed) taken at different times during the grazing period, that the younger pasture had a better quality. The digestibility of the fistula 1-year-old samples remained significantly higher throughout the grazing season than that of the clipped samples. This is due to the selectivity of animal grazing on a material that offers higher quality. The sheep on the older pasture were, however, unable to select as high a quality and there was little or no difference between fistula and clipped samples.

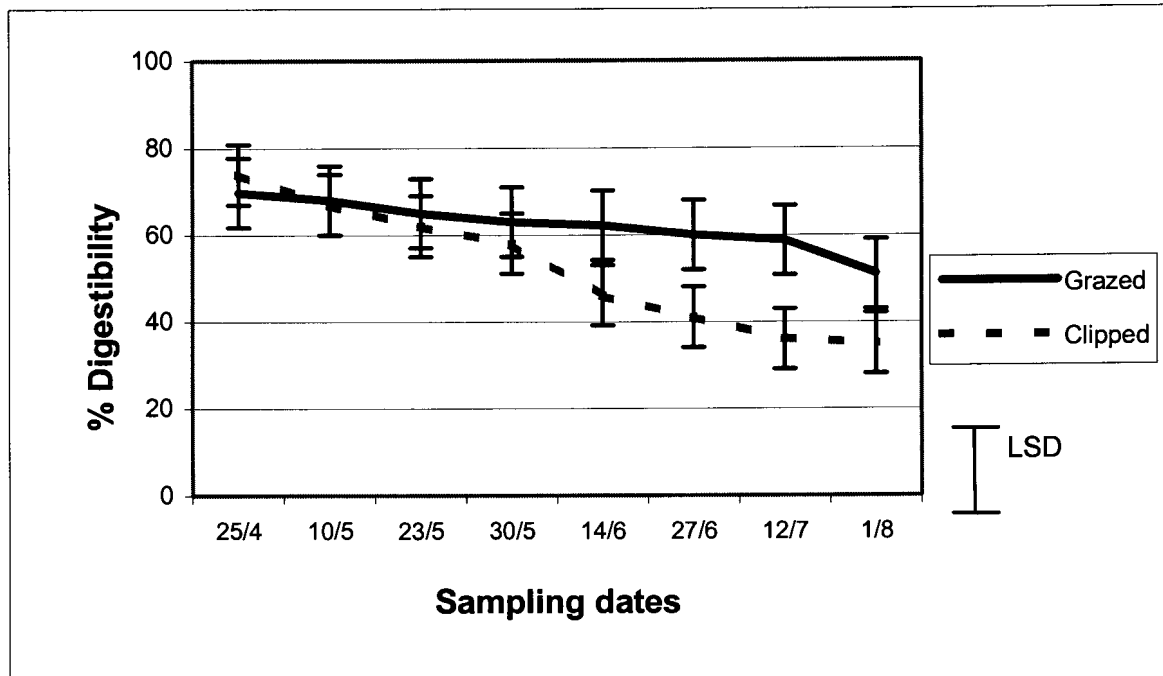


Figure 3 A comparison of *in vitro* digestibility (%) of 1 Year old Silk samples obtained from clippings and fistulated sheep during the winter grazing period.

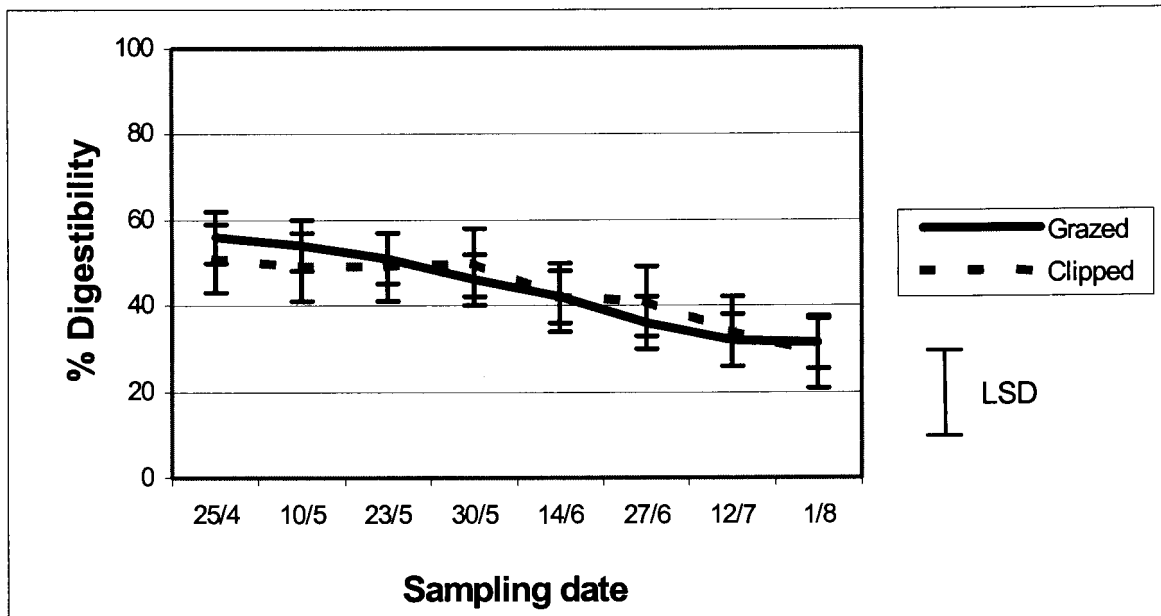


Figure 4 A comparison of digestibility (%) of 2 Year old Silk samples obtained from clippings and fistulated sheep during the winter grazing period.

Conclusions

The yields registered in Pretoria demonstrated the potential of Silk to produce good yields of a high quality forage under dryland conditions. Older pastures produced more material than younger stands. This, however, resulted in a reduction in quality.

Animals were able to select a high quality diet in autumn but this declined as the availability become more limiting. Depending on the particular production system of the farmer and the requirements of different livestock classes, Silk

may be used to provide a younger material of higher quality or more material of lower quality. The major trouble with Silk sorghum is the alleged infestations into other crops (cultivar decline) because of its close relationship with Johnsongrass.

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Chapter 3

Prepared according to the guidelines of the African Journal of Range & Forage Science

A Comparison of Coastcross II (*Cynodon* hybrid), P66 Creeping finger grass (*Digitaria eriantha* subsp *pentzii*) and Smutsfinger grass (*Digitaria eriantha* subsp *eriantha*) as foggage

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Abstract

In this trial three pasture species (Coastcross II (KII), a creeping finger grass (P66) and Smutsfinger grass) were compared as foggage. This was based on plant based observations (clipped samples) as well as animal based observations (fistulated sheep) to determine quantitative and qualitative parameters. 100kg N/ha was applied as a single application at the start of the trial in mid-summer. Of the three pastures KII had the highest yield although P66 was also impressive. Smutsfinger grass had the lowest % leaf throughout the trial, but because of its higher acceptability for animals it had the lowest post winter residue. P66 was the surprise with the highest % leaf in winter due in part to its creeping nature. Smutsfinger grass, however, had the highest digestibility and would thus be the first choice as foggage for maintaining animals through winter.

Additional index words: Standing hay, stockpiled pasture, winter feed.

Introduction

The shortage of adequate, good quality herbage during the winter months, is one of the biggest problems confronting stock farmers in the summer rainfall areas of South Africa. Animal scientists agree that poor winter-feed is responsible for the generally low animal production in South Africa (Dannhauser 1991). Foggage (also described as standing hay or stockpiled pasture) might provide the solution to this problem, when managed correctly.

Some writers are of the opinion that foggage can not replace fodder resources such as hay and silage, especially for high producing animals (Brockett 1983; l'ons 1988). If animals can survive winter on foggage with minimum weight loss, such livestock have the advantage that their growth, during the following summer, will be much faster and better than animals which have lost considerable weight during the winter. The four most important factors influencing quantity and quality of foggage, are the species, fertilisation, resting period and stage of utilisation. Species selection is probably one of the most important factors.

The three grass species - Coastcross II, P66 and Smutsfinger grass - discussed in this chapter are well known in South Africa. They have the potential to produce a high quality foggage because of their palatability, production of leaf material and a high crude protein level throughout the winter (Barnes 1966; Dannhauser 1991). This ensures not only a stable animal mass, but also an average daily gain (ADG) of note in some cases. Rethman and Gouws (1973) reported mass gains of 570 g/animal/day by young steers on Kikuyu foggage.

Species characteristics

Coastcross II or “K11” (*Cynodon* hybrid)

The first Coastcross II material was imported into South Africa in 1961. Since then considerable research has been done locally – especially in Natal. This species originated in America where it was bred from the Giant Bermudas also known as “Coastal”. This cross between Giant Bermuda and a *Cynodon* selection from Kenya was the basis of “Coastcross” (Bogdan 1977). K11 is a sterile hybrid and is therefore propagated vegetatively. Rhizomes are not as common in K11 with the result that it can be destroyed more easily than other creeping grasses. Because K11 is described as a creeper, it forms a dense sward and can, therefore, be used for hay or foggage production (Dannhauser 1991).

K11 which is a finer grass than Star grass, is also more cold and drought resistant and grows on poorer soils (Dickinson *et al*, 1990). It is suggested that K11 grows better on sandy soils, but it is also regularly found on heavy clay soils. This grass can tolerate an average rainfall of 550 mm, but has, however, survived periodic droughts with much lower rainfall. Production figures of more than 20 t/ha (dry material) under irrigation are possible, but are the exception. The pH of the soil only becomes detrimental to production when it drops below 4.0 (Williams 1981). This grass type is ideal for sheep grazing, although it is also suitable for beef and dairy cows. The protein content of young material varies between 9% - 18%, with a digestibility between 51% and 65% (Dickinson *et al*. 1990).

Smutsfinger grass (*Digitaria eriantha* ssp. *eriantha*)

Smutsfinger grass has been one of the most popular pasture grasses since the 1970's and it can, to date, be seen as the best-known summer grass in the summer rainfall areas of South Africa. It was first observed in 1924 by Genl. Jan Smuts at Pretoria (Dannhauser 1991). The best known cultivar of this grass is Irene, and is very popular with farmers.

This tufted species is very palatable, grows up to 3m high and produces a large quantity of leaf material (Gibbs-Russell *et al.* 1990). The important conditions for the utilisation of Smuts finger grass as foggage, are that it should be rested from mid-January for the remainder of the growing season. If it is going to be fertilised, then January is the correct time (Dannhauser 1991). With an average rainfall of 500 mm per year and more, Smuts finger can be established successfully. Although it is sensitive to rainfall, it can survive temperatures as low as -10°C (Dannhauser 1991). This grass establishes exceptionally well on rocky soils, but as with most fine seeded grasses with some difficulty on heavy clay soils. Less fertiliser can be used under dry conditions, because of the palatability of the grass. Although the production will be lower, animals will still utilise the material – especially as foggage. Production figures as high as 12 – 18 t/ha under good climatic condition have already been reported. Smutsfinger should not be defoliated to less than 50 mm, if sustainable production is to be achieved (Drewes 1982).

P66 Creeping finger grass (*Digitaria eriantha* ssp. *pentzii*)

This finger grass selection had its origin in the Thabazimbi district. The growth form is creeping which is different from the well-known Smuts finger grass. The P66 refers to the original accession number allocated at the Rietondale

Pasture Research Station. P66 is one of four selections made after evaluations at Rietondale (Pretoria), the Nooitgedacht Research Station (Ermelo) and the Hatfield Experimental Farm of the University of Pretoria from the original collection of 60 accessions.

Material and Methods

Site

Pure stands of KII, P66 and Smutsfinger grass were established on the Field Experimental Section of the Hatfield Experimental Farm of the University of Pretoria. The farm is situated 1353m above sea level at coordinates 25° 45' South and 28° 16' East, in a summer rainfall area with a long-term mean annual precipitation of 708 mm. The soil form is Hutton (MacVicar *et al.* 1977) with a weak structure and a homogenous red colour and is non-calciferous. The soil can be described as a sand-clay-loam with 20% – 35% clay content.

Layout

The three species were well established when the trial started. Each species was planted in three randomly allocated paddocks of 0.0613 ha each. The size of the different paddocks provided enough material to ensure replicated sampling. 100 kg/ha Nitrogen (N) was applied as one application at the start of the trial in mid-summer and, as the soil samples indicated that there was no shortage of phosphorus (P) or potassium (K), P and K were not applied.

Collection of data

Plant based observations

Pasture availability was determined:

- (a) in mid-summer, when the production in the first half of the growing season was determined by clipping six replicated quadrats (1m² each) in each paddock, prior to being mown and fertilized;
- (b) in autumn, when the standing crop in terms of DM yield and leaf / stem ratio's was determined on similar quadrats to describe the pasture prior to the commencement of winter grazing and
- (c) in winter, when the residue after winter grazing was assessed, in terms of yield and leaf / stem ratio's on six replicated quadrats in each paddock.

Pasture quality (of clipped samples) in terms of crude protein (CP) and *in vitro* digestibility (IVDOM), was determined for both leaf and stem components in summer, autumn and winter. CP was calculated (% N x 6.25) after % N was determined using the Kjeldahl technique (AOAC 1995), while *in vitro* digestibility of OM was determined using the technique of *in vitro* fermentation as described by Tilley and Terry (1963), as modified by Engels *et al.* 1981).

Animal based observations

The three pastures, which were stockpiled in the late summer, were grazed (as foggage) from ± 10 April 2000 to the beginning of August 2000. Grazing was by sheep stocked according to the availability of feed to ensure that comparable grazing pressures (amount of feed / animal unit) were applied on different pastures. A standard drenching and inoculation program to eliminate parasites or diseases as confounding factors was followed. No mineral, protein or energy supplementation was provided.

After a two week adaptation period (necessitated by the fact that the sheep had been on a milled, stall-fed ration prior to being placed in the experimental pastures) liveweight data was collected at regular intervals (26/4, 11/5, 25/5, 01/6, 15/6, 29/6, 13/7 and 26/7) to assess the variation in the quality of foggage over the winter grazing period. At each date two oesophageal fistulated sheep were also used to obtain samples of material selected by the grazing animal. The following procedures were followed in the collection of these samples: the fistulated sheep were placed in the designated paddock for ± 2 hours together with other sheep, then fistula samples were collected, the excess moisture was squeezed out, the samples were then placed in bags to be freeze-dried and milled. These samples were then analysed for IVDOM using the procedures described. At the same time as fistula samples were collected clipped samples (to try and simulate animal selection) were also collected and analysed for comparative purposes.

Analysis of data

An analysis of variance with the Proc-GLM model (SAS 1996) was used to determine differences between treatments. Least Square Difference (LSD) were used and the level of significance was tested with the Bonferroni test (Samuels 1989).

Results and Discussion

Availability of forage

Although Smutsfinger grass produced a fair amount of leaf material, it was generally less than that of KII because of its tufted growth form and a high

tiller production. Unexpectedly (Literature Review), P66 also tended to have a higher leaf yield than Smutsfinger, because of its creeping characteristic. This was substantiated by the yield data generated in this study (Table 1). KII had the best production from summer to winter, with P66 also impressive in the autumn harvest. Smutsfinger had a lower yield than the two creeping species. Yield is not, however, the only parameter for a good foggage pasture. structure and quality might favour Smutsfinger grass.

Table 1 The dry matter yields (t DM/ha) of KII, P66 and Smutsfinger grass pastures at different stages

Age	Season		
	Summer	Autumn	Winter
KII	4.8 ^a	9.4 ^c	6.9 ^b
P66	1.5 ^o	7.2 ^m	2.9 ⁿ
Smuts	1.3 ^q	3.6 ^p	1.8 ^q

Values in rows with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

The production was significantly better in the late summer (autumn harvest) than in the early summer (summer harvest) (166% higher average yields). Whilst the early growing season growth could be used for grazing, hay or silage – dependent on the needs of the farmer – the late season growth was utilised as foggage / standing hay in the winter. It would appear that the

Smutsfinger and P66 were more palatable than the KII, as foggage as more residue was left on the KII (73% compared with 50% and 40% respectively). Smutsfinger is known for its palatability and it appears that P66 also has similar properties. But as stated by Drewes (1982) that Smutsfinger shouldn't be defoliated less than 50 mm, this might be the reason for the low winter yield of Smutsfinger as well as the higher palatability (Literature Review).

% Leaf in available forage

The % leaf in the late summer growth was higher than the early summer growth in all three species, with an expected decline in the proportion of leaf in residues left after winter grazing (see Table 2). Smutsfinger grass had the lowest proportion of leaf throughout the trial. KII was very leafy especially in autumn (Literature Review). P66 had the highest % leaf in residues, indicating a similar palatability for the leaf and stem components of this grass.

Table 2 The % leaf (DM) of KII, P66 and Smutsfinger grass during early and late summer and at the end of the winter grazing period

Age	Season		
	Summer	Autumn	Winter
KII	55% ^b	78% ^a	58% ^b
P66	43% ^o	67% ^m	62% ⁿ
Smuts	33% ^r	53% ^p	41% ^q
Average	44%	64%	54%

Values in rows with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Quality of available forage

The quality of the species in terms of crude protein content (see Table 3) was the best in summer with leaves having a better CP than stems. The frost and senescence of the pastures induced a decline in CP content of both leaves and stems. P66 leaves had a decline of 17% from mid summer to autumn, where KII and Smutsfinger leaves had declines of 41% and 40% respectively. The CP of Smutsfinger grass leaves declined further from autumn to the end of winter by 25% CP, while the CP of KII and P66 leaves declined by 50% and 36% respectively. This was correlated with the decline in CP content of animal selected material, which declined by 4%, 30% and 37% for Smutsfinger, KII and P66 respectively.

The material selected by the sheep was always of a higher quality than the clipped material in both autumn and winter. Fistulated samples averaged a CP content of 14% in autumn and 11% in winter, where-as clipped samples averaged 6% and 4% in autumn and winter respectively. This again demonstrates the value of animal selected samples above experimental clippings. Thus all three of the species had a relative high quality when evaluated by fistula samples rather than clippings (Literature Review).

Table 3 The percentage crude protein (% CP) in leaf, stem and fistula samples of KII, P66 and Smutsfinger grass at various stages

Age and structure		Summer	Late Autumn	Winter
KII	(Leaves)	15.7% ^a	9.2% ^m	4.6% ^q
P66	(Leaves)	9.4% ^b	7.8% ⁿ	5.0% ^q
Smuts	(Leaves)	12.6% ^c	7.6% ⁿ	5.7% ^p
KII	(Stems)	9.0% ^b	4.0% ^o	2.6% ^r
P66	(Stems)	6.8% ^e	4.5% ^o	2.9% ^r
Smuts	(Stems)	8.0% ^d	4.0% ^o	3.8% ^q
KII	(Fistula)	-	16.8%	11.8%
P66	(Fistula)	-	11.7%	7.4%
Smuts	(Fistula)	-	13.7%	13.2%

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

The *in vitro* digestibility of KII and P66 leaves (see Fig. 1) declined from summer through autumn to late winter, but stayed basically the same for Smutsfinger grass. KII had the lowest digestibility of the three pastures. The *in vitro* digestibility of stems (Fig. 2) declined from summer onwards, but was much lower than that of the leaves. The digestibility of stem material of the different pastures was, however, nearly the same by the end of winter.

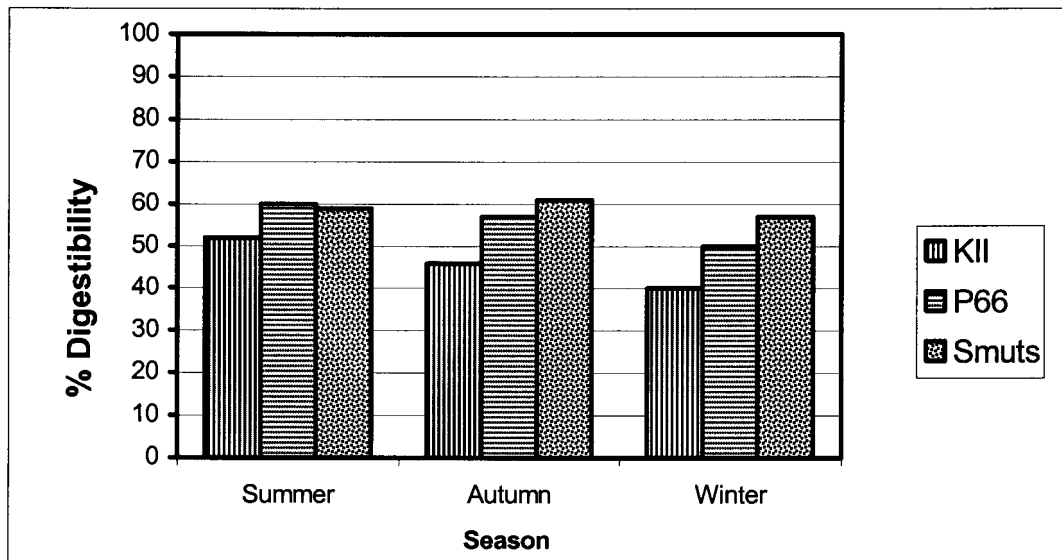


Figure 1 *In vitro* digestibility (%) of KII, P66 and Smutsfinger grass leaves from clipped samples.

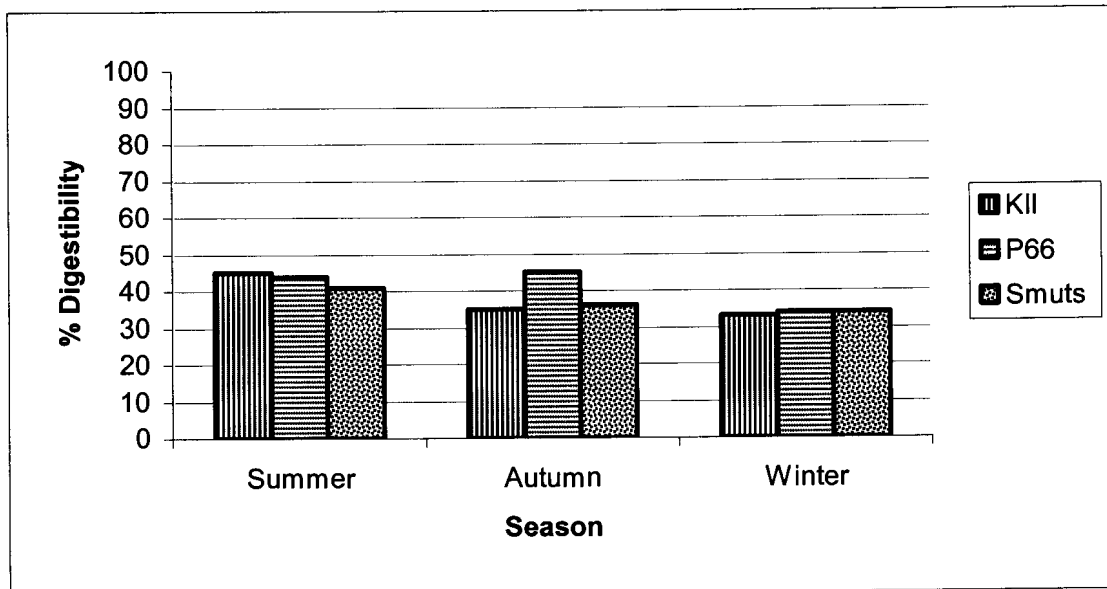


Figure 2 *In vitro* digestibility (%) of KII, P66 and Smutsfinger grass stems from clipped samples.

It is also evident from Figures 3, 4 and 5 which illustrate the *in vitro* digestibility of fistula samples taken at different times during the winter grazing period on the different pastures, that the animal selected pasture had a better quality than clipped samples. This is due to the selectivity of the grazing animals. P66 had the highest digestibility at the beginning of the trial but this declined gradually like the other two pastures. KII had the lowest digestibility at the end of the trial, although it had a relative high % leaf in winter. Smutsfinger grass had the lowest yield and % leaf of the three species, but had the best average digestibility from summer to winter indicating the palatability and the value of this species (Literature Review).

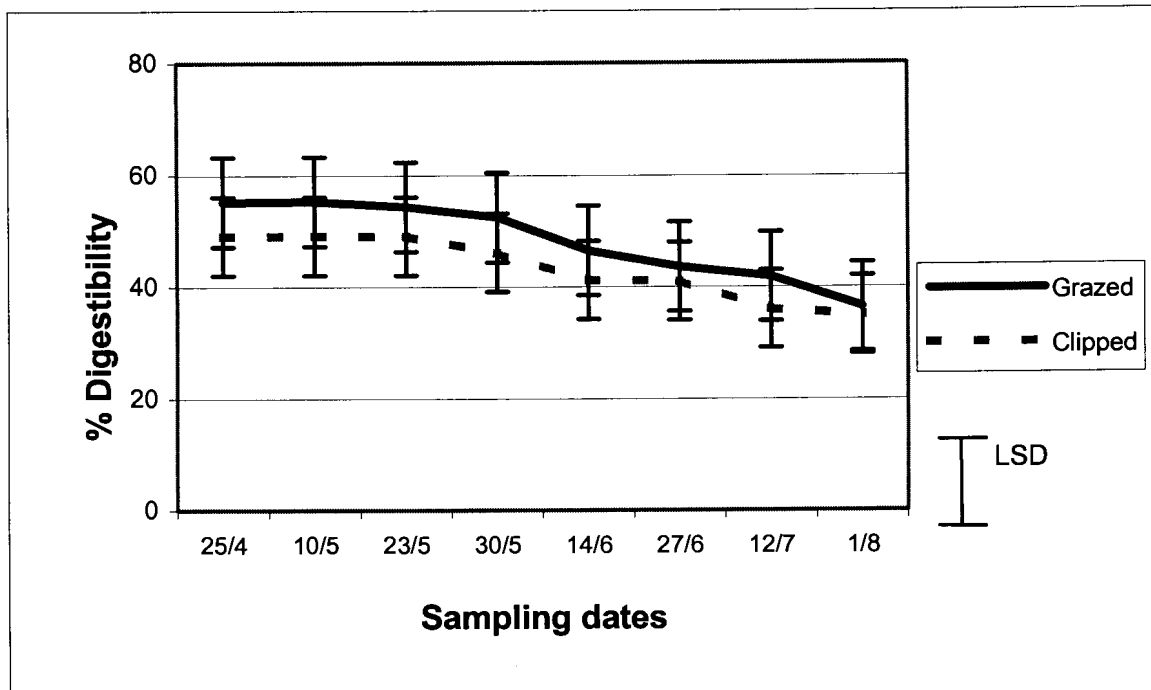


Figure 3 A comparison of *in vitro* digestibility (%) of KII samples obtained from clippings and fistulated sheep during the winter grazing period.

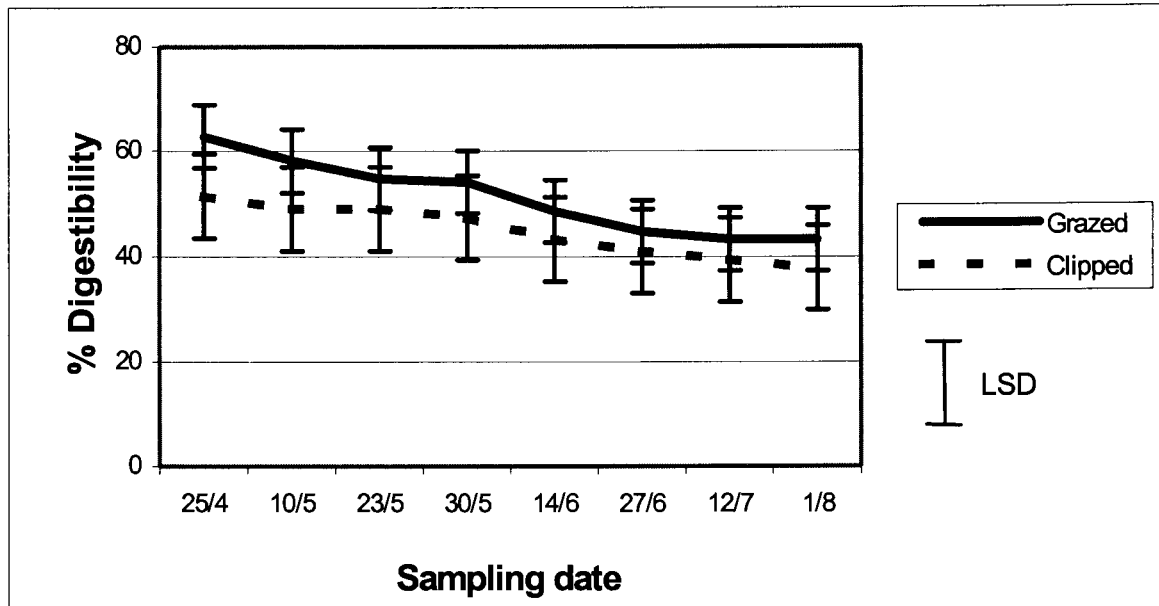


Figure 4 A comparison of *in vitro* digestibility (%) of P66 samples obtained from clippings and fistulated sheep during the winter grazing period.

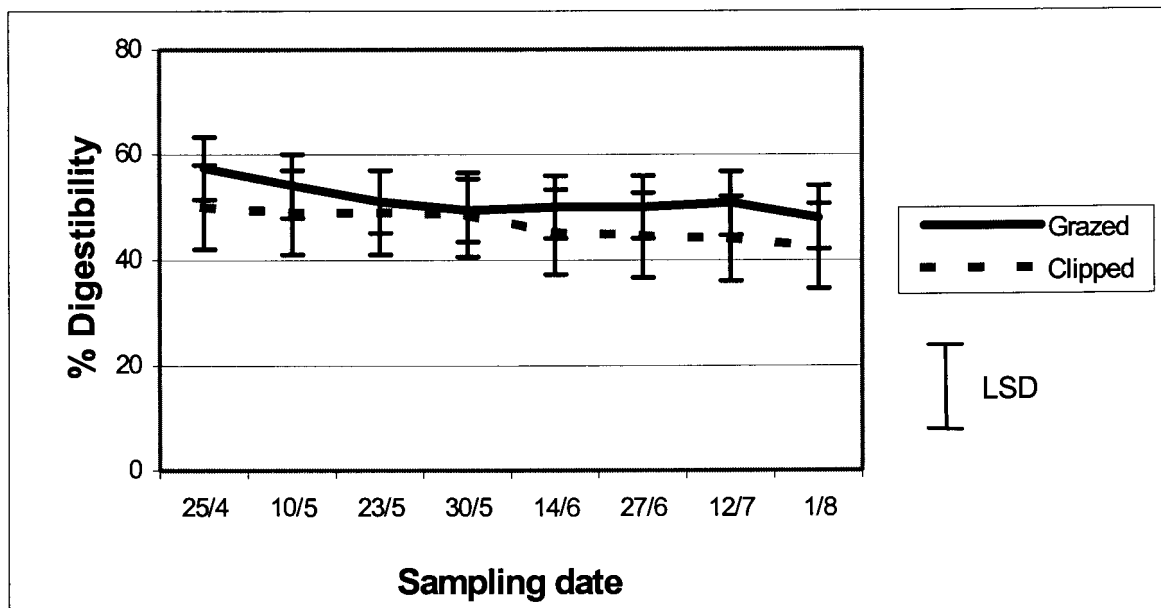


Figure 5 A comparison of *in vitro* digestibility (%) of Smutsfinger grass samples obtained from clippings and fistulated sheep during the winter grazing period.

Conclusions

The results obtained in this trial indicate the value of all three selected pasture species for their foggage potential. Although Smutsfinger grass produced a fair amount of leaf material, it was less than that of KII because of its tufted growth form and a high tiller production. P66 also has a higher leaf material yield than Smutsfinger grass.

KII had the best yield of the three pastures, with P66 also impressive in the late summer. Smutsfinger grass had the lowest % leaf throughout the trial, but due to its high acceptability for animals it had a low residue after winter grazing. KII was very leafy especially in the autumn, but P66 had the highest % leaf in winter due to its creeping nature and high leaf production.

Smutsfinger grass outperformed the other two species in terms of digestibility and would thus be the first choice for maintaining animals through winter. All three species had a relative high quality (CP content) when evaluated by fistula samples rather than by clippings. This trial underscores the importance of animal based observations in addition to plant based observations.

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Chapter 4

Prepared according to the guidelines of the African Journal of Range & Forage Science

Comparison of *Digitaria eriantha* ssp *eriantha*, *Panicum coloratum* cv. Selection 75, *Panicum maximum* cv. Gatton and *Bothriochloa bladhii* for utilisation as foggage

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Abstract

In this trial four pasture species – Smutsfinger grass (*Digitaria eriantha*), Kleingrass (*Panicum coloratum*), Guinea grass / White Buffalo grass (*Panicum maximum*) and Purple plume grass (*Bothriochloa bladhii*) - were compared as foggage. This was based on plant material observations (clipped samples) to determine quantity, structural and quality parameters. 80kg N/ha was applied as one application at the start of the trial in mid-summer. Guinea grass had the best DM yield with Purple plume grass also impressive. Guinea grass, however, had the lowest % leaf in winter, with Smutsfinger grass and Purple plume grass more impressive. Although Purple plume grass performed well in this comparative trial, many of the species belonging to this genera are not as palatable and acceptable as the other three species. Kleingrass appears to be a good compromise between the sensitive, high producing

Guinea grass and high quality Smutsfinger grass, as it is also well adapted to more arid areas.

Additional index words: Standing hay, stockpiling, White Buffalo grass, winter feed.

Introduction

In many regions that are suitable for warm-season grasses, many producers - especially those with introduced warm-season grasses – have not realized the value of these forages as foggage. Stockpiling warm-season forages means managing them to accumulate standing forage for later grazing, in this case, during winter. The most common use for foggage is as a fall-to-spring grazeable pasture alternative to hay and a complete or partial replacement for winter hay. Forages are also foggaged during the spring growing season to provide grazing during midsummer drought and slower forage production periods (Dalrymple 2000).

Most forages can provide some feed value if it is properly grazed and the livestock are given adequate feed supplements. There is no reason why most classes of livestock could not be kept on foggage if the pasture is managed correctly (Johnston *et al.* 1998). The four species (*Digitaria eriantha*, *Panicum coloratum*, *Panicum maximum* and *Bothriochloa bladhi*) selected for this study offer various degrees of quality material and can be used as foggage in the autumn / winter period.

The following characteristics of these species are important when assessing the value of each and should be considered together with their production potential and quality when estimating their value:

- *Digitaria eriantha* (Smutsfinger grass) is a highly palatable species which is often used as hay but which also provides a high quality foggage (Dannhauser 1987). Smutsfinger grows on all types of well-drained soil. It is adapted to areas with an annual rainfall of 600mm and more, reacts well to fertilisation and is relatively tolerant of heavy grazing. With fertilisation of 400kg N/ha, a yield of 24 t/ha/year may be reached (Rethman 1983).
- *Panicum coloratum* (Kleingrass) is a summer-growing perennial species that is extremely well adapted to drought (400mm + rainfall/year), because of a deep, fibrous root system (Sauer & Sons 1992). The other outstanding feature of this species is its ability to remain relatively green and palatable during winter and to withstand heavy grazing (Humphreys & Partridge 1995). It's also well adapted to heavy clay soils and waterlogging (Lambert & Graham 1996).
- *Panicum maximum* (Guinea grass) is a tall perennial grass with a deep root system that enables it to withstand droughts but not for long spells (Lambert & Graham 1996). It's a more leafy grass than Smutsfinger and has a higher production potential in certain specific areas (Dannhauser 1987). Guinea grass is tolerant of shade which broadens its range of adaptation (Sauer & Sons 1992). It has, therefore, the potential to make better foggage than Smutsfinger, but has some problems with trampling when used as foggage (Fair 1986).
- *Bothriochloa bladhii* (Purple plume grass) is related to *B. radicans* and *B. insculpta*, which are generally unpalatable due to high concentrations of aromatic compounds. The Australian form of *B. bladhii* (a less aromatic

equivalent), however, has become a valuable pasture grass and is widely used in the south western states of the U.S.A. It is renowned for its high leaf production and ability to grow on clay soils and, therefore, has the potential to provide good quality foggage.

Material and Methods

Site

Pure swards of Smutsfinger grass, Kleingrass, Guinea grass and Purple plume grass were already established on the Field Experimental Section of the Hatfield Experimental Farm of the University of Pretoria. The farm is situated 1353m above sea level at the coordinates 25° 45' South and 28° 16' East in a summer rainfall area with a long-term mean annual precipitation of 708 mm. The soil form is Hutton (MacVicar *et al.* 1977) with a weak structure and a homogenous red colour and is non-calciferous. The soil is described as a sand-clay-loam with 20% – 35% clay content.

Layout

The area utilized for this experiment contained 48 plots of 20m² (5m x 4m) each. The allocation of the four species to plots was in a randomized block layout with 12 plots per species. The area used was level and homogenous in terms of soil and topography. Effects of these factors could, therefore, be discounted and differences between grass species in terms of production and quality could, therefore, be ascribed to interspecific variation. This area had already been established four years prior to this trial and this was to have a crucial effect on the results.

The 48 blocks were mown in March 2000 and then fertilised with a standard nitrogen application of 80kg N/ha applied in the form of limestone ammonium nitrate (LAN 28%). There were no shortages of phosphorus (P) and potassium (K) indicated by soil analyses.

Collection of data

Foggage production, or pasture availability was determined:

- (a) in late-summer (end of March), when the production was determined by clipping six replicated quadrats (1m² each) of each species, to determine quantity, quality and structure; and
- (b) in winter (end of July), when the entire sampling and processing procedure was repeated to again evaluate the foggage value of the pastures.

Pasture quality (of clipped samples) in terms of crude protein (CP) and *in vitro* digestibility (*in vitro* Digestible Organic Matter - IVDOM), was determined for both leaf and stem components in autumn and winter. Crude protein was calculated (% N x 6.25) after % N was determined using the Kjeldahl technique (AOAC 1995), while the *in vitro* digestibility of organic matter (OM) was determined using the technique described by (Tilley & Terry 1963 as modified by Engels 1981).

Analysis of data

An analysis of variance with the Proc-GLM model (SAS 1996) was used to determine differences between treatments. Least Square Difference (LSD) was used and the level of significance was tested with the Bonferroni test (Samuels 1989).

Results and Discussions

Availability of forage

In evaluating these species in terms of forage, the production potential and quality attributes should be combined with the circumstances in which they are likely to be grown. This must be done to obtain a holistic estimation of their likely performance.

Table 1 The dry matter availability (t DM/ha) of Smutsfinger grass, Kleingrass, Guinea grass and Purple plume grass as measured in late-summer and winter

Species	Season	
	Late-summer	Winter
Smutsfinger	3.0 ^a	2.8 ^x
Kleingrass	3.5 ^{ab}	2.8 ^x
Guinea grass	3.8 ^b	3.8 ^y
Purple plume	2.7 ^a	3.1 ^x

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

In terms of production in the late summer growing period, Guinea grass gave consistently higher yields than the other three species at both sampling times (Literature Review). Some of the Guinea grass plots had, however, become a bit sparse as the trial has aged. This reinforces the observation that this species is sensitive to management. If *P. maximum* is properly managed, it is undoubtedly the highest producing of the four species (Lambert & Graham 1996). It, however, still lacks the resilience and persistence of Purple plume grass (*B. bladonii*) and Kleingrass (*P. coloratum*). It also appears that Smutsfinger grass (*D. eriantha*) requires careful management, whereas *B. bladonii* was the least affected by low levels of management over the four to five years since establishment. *P. coloratum* appears to be intermediate in terms of persistence, whilst there were no significant differences in the late summer growth of Smutsfinger, Klein or Purple plume grasses.

P. maximum should, therefore, be recommended in areas where this sensitive species is well adapted and well managed enabling it to produce to its full potential. For production of consistent quantities of foggage where management inputs are lower, *B. bladonii* and *P. coloratum* would be recommended.

% Leaf in available forage

Although Purple plume grass had a greater proportion of leaf than the other species in the winter (Table 2), its palatability is, by association, under suspicion (Literature Review). Smutsfinger grass would appear to be a better choice in that it has a consistently high proportion of leaves in both summer to winter. Of the three presumably more palatable species, Kleingrass will

probably do better in more arid areas, as it is adapted to drier conditions. It is reputedly also more tolerant of heavy grazing and hence has lower management requirements.

Table 2 The % leaf in Smutsfinger grass, Kleingrass, Guinea grass and Purple plume grass sampled in late-summer and winter

Species	Season	
	Late-summer	Winter
Smutsfinger grass	58 % ^a	57 % ^x
Kleingrass	57 % ^a	41 % ^y
Guinea grass	57 % ^a	35 % ^y
Purple plume grass	52 % ^b	68 % ^z

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Quality of forage

The crude protein content of both leaves and stems (Table 3) of all four species was higher in late-summer than in winter. Understandably the CP content of leaves was also markedly higher (59%) than that of stems. This again emphasizes the importance of a high leaf proportion. Smutsfinger grass and Guinea grass had a significantly better leaf protein in the winter, while Guinea grass stems contained the most protein in the late-summer.

Table 3 The percentage crude protein (% CP) of Smutsfinger grass, Kleingrass, Guinea grass and Purple plume grass components in late-summer and winter

Age and structure	Late-summer	Winter
Smuts (Leaves)	14.1% ^a	11.8% ^x
Klein (Leaves)	13.0% ^b	8.9% ^{xy}
Guinea (Leaves)	14.0% ^a	10.9% ^x
Purple (Leaves)	13.9% ^a	8.5% ^y
Average	13.8%	10.0%
Smuts (Stems)	7.5% ^d	6.2% ^z
Klein (Stems)	6.2% ^e	5.7% ^z
Guinea (Stems)	11.4% ^c	6.3% ^z
Purple (Stems)	9.8% ^{cd}	7.0% ^{yz}
Average	8.7%	6.3%

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

With respect to *in vitro* digestibility (see Fig.1), Purple plume grass had the highest leaf digestibility in late-summer (Literature Review), but this was, unfortunately, the lowest in winter. Guinea grass and Smutsfinger grass tended to have the best leaf quality in the winter, with Kleingrass and Purple plume grass only marginally poorer.

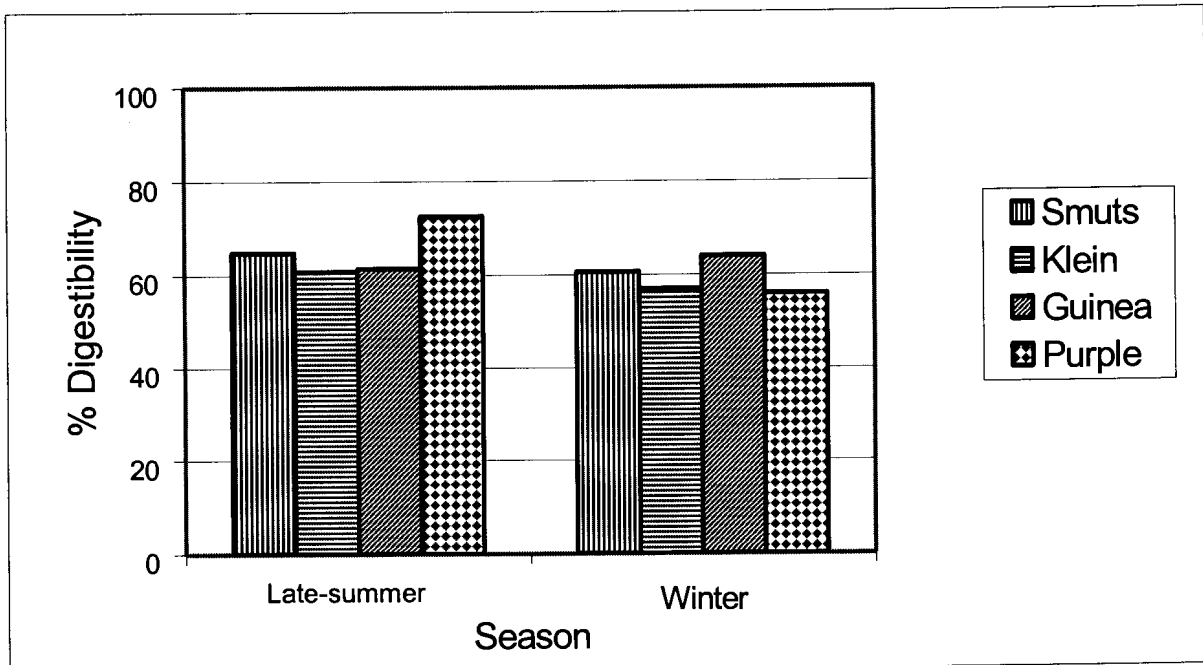


Figure 1 *In vitro* digestibility (%) of Smutsfinger grass, Kleingrass, Guinea grass and Purple plume grass leaves from clipped samples in the late-summer and winter months.

Although Guinea grass had the highest % leaf, it disappointingly had a poor average digestibility because of a very poor stem digestibility in winter (Literature Review). Smutsfinger tended to produce the best average quality of the four species and is likely to be the better choice for foggage production.

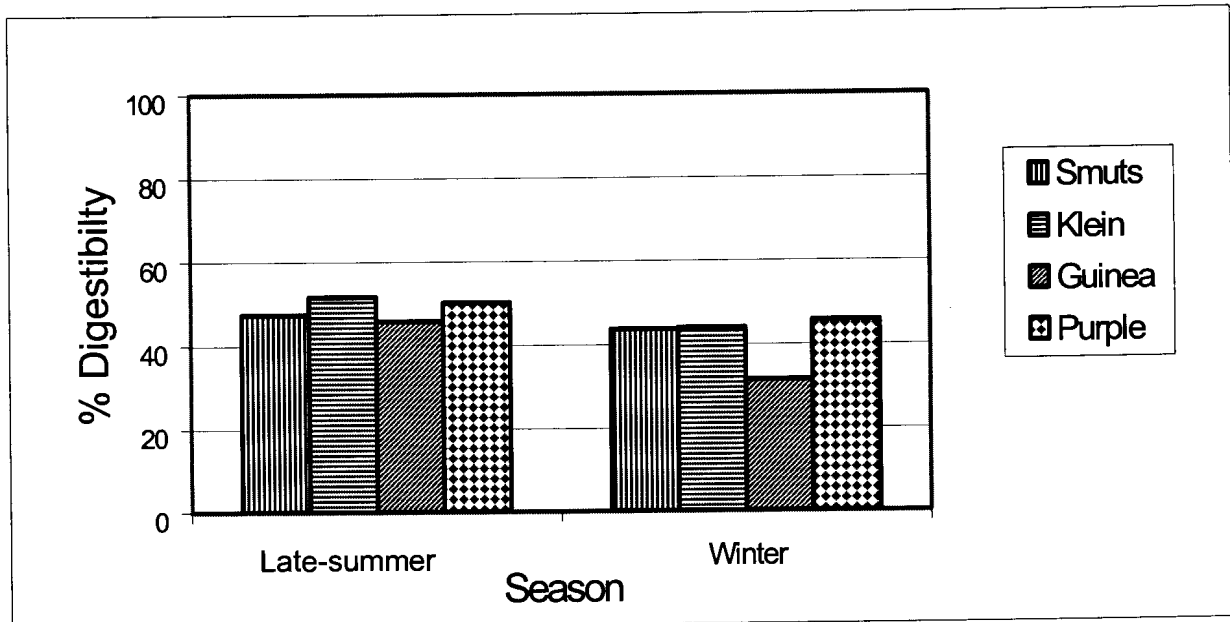


Figure 2 *In vitro* digestibility (%) of Smutsfinger grass, Kleingrass, Guinea grass and Purple plume grass stems from clipped samples in late summer and winter.

Conclusions

As expected from earlier observations (Sanderson *et al.* 1999), Purple plume grass compared very well with the other well-known foggage species. It produced an average yield, had a high proportion of leaf in winter and had an average CP content and digestibility. But *Bothriochloa* species are, however, generally less palatable, due to high concentrations of aromatic compounds. A grazing trial would, therefore, be recommended to evaluate *B. bladhii* in terms of palatability and animal performance relative to other species.

From this trial it is evident that the other three species are all good choices for utilisation as foggage. In comparative terms, Guinea grass had the most material available with the highest crude protein in winter, but had the lowest proportion of leaf with a lower average digestibility. If *P. maximum* is properly managed, it is undoubtedly the highest producing of the three species. But it lacks the resilience and persistence of Purple plume grass (*B. bladhii*) and Kleingrass (*P. coloratum*). It would seem that *D. eriantha* also needs relatively high management skills whereas *B. bladhii* seems to be the least affected by management. *P. coloratum* appears to be intermediate between the sensitive, high producing *P. maximum* and the persistent lower producing *B. bladhii*.

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Chapter 5

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A comparison of *Cenchrus ciliaris* accessions as foggage and the effect of nitrogen fertiliser on foggage value

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Abstract

The foggage value of *Cenchrus ciliaris* was studied in two trials. In trial 1, five accessions (Molopo, Arusha, Makayuni, 409704 and Worcester) were compared to determine the best in terms of plant based observations. The cultivar Molopo was evaluated in trial 2 in terms of different fertiliser application rates (0, 50, 100 and 150 kg N/ha) to gather production data for on farm management planning decisions. As expected, Molopo performed the best in comparison to other cultivars under local conditions but specific area adaptability may suit other accessions. The application of high N fertiliser rates in trial 2 resulted in better foggage quantity and quality. It is, however, for the farmer to decide what input costs his management plan can accommodate. It is, therefore, recommended

that high levels of N fertiliser be applied to ensure good foggage quality and animal performances.

Additional index words: Blue buffalo grass, crude protein and standing hay.

Introduction

From the early 1900's, grassland productivity has declined, soil erosion has increased and drought has destabilised the livestock industry in both the northern and southern hemispheres. This has led to a decline in animal numbers throughout the world and man has, therefore, had to improve animal feed production to maintain more animals to meet the needs of the ever-increasing human population (Cox *et al.* 1988).

It is unlikely that foggage will ever completely replace the use of hay or silage, but it has a definite role to play in maintaining animals through the dormant season. Grasses can also survive in more arid regions and can, therefore, produce an animal feed of relatively good quality, where maize production is not feasible.

Cenchrus ciliaris

Of the grass species used as foggage around the globe, Buffelgrass is certainly one of the most drought tolerant species used in the semi-arid areas of Africa, Australia, North America and South America (Brooks 1929, Bogdan 1961 and Cox *et al.* 1983). Buffelgrass originated from semi-arid northeast Africa (northcentral Kenya and southern Ethiopia), where C.J.J. van Rensburg

(Department of Agriculture, South Africa) collected seed between 1940 and 1945. Seed collections were planted in the U.S.A. and the U.S. Department of Agriculture together with the Soil Conservation Service (USDA-SCS) informally released T-4464 buffelgrass in 1949. T-4464 as well as seed from other buffelgrass collections made in Pakistan and southern Africa (Ivory *et al.* 1974) were shipped to Australia where they were successfully established (Humphreys 1967). Various buffelgrass accessions have been selected for production and specific tolerances over the years – more than 863 accessions at the moment (GRIN 2001). In order to improve productivity and vigour in extreme conditions of drought, disease, frequent fire and other factors, numerous cultivars have been identified. Molopo originated in the Molopo valley. This selection makes *C. ciliaris* suitable for a wide array of specific habitats around the world. For example, in Australia, *C. ciliaris* occurs in moist riverine habitats (D'Antonio & Vitousek 1992) and has survived up to two weeks under water (Anderson 1970).

The genus name, *Cenchrus*, was derived from the Greek word *kegchros*, meaning millet because *Cenchrus* is very similar to the genus *Pennisetum*. It is a perennial tufted species (erect culms of 10 – 150cm) which is generally found growing in environments with elevations of 150 to 800m above sea level. It can form thick mats or tussocks with dense, often stoloniferous growth form and variations of bluish-green leaf blades (Van Devender *et al.* 1997). The mean monthly minimum and maximum adaptation temperatures vary from 21° to 24°C and 31° to 36°C, respectively. Rainfall adaptations vary annually from 200 to

450mm (maximum of 1250mm) and growth occurs whenever soil moisture is available (Cox *et al.* 1988). This drought tolerant species responds quickly to light falls of rain. Buffelgrass prefers growing in loam and sandy clay loam soils and seed may remain viable for up to three years (Winkworth 1963, Wagner *et al.* 1990). *C. ciliaris* is preferred because of its nutritional value for livestock, it can withstand heavy grazing, tolerate relatively low pH's and is extremely fire resistant (Mayeux & Hamilton 1983). There are no serious pest problems except for limited fungal blight, but buffelgrass itself poses a threat as a weed in many areas around the globe (Low 1997, Perrott & Sukumar 1999, Rao *et al.* 1996).

Material and Methods

Site

Stands of buffelgrass were already established on the Field Experimental Section of the Hatfield Experimental Farm of the University of Pretoria. The farm is situated 1353m above sea level at the coordinates 25° 45' South and 28° 16' East in a summer rainfall area with a long-term mean annual precipitation of 708 mm. The soil form is Hutton (MacVicar *et al.* 1997) with a weak structure and a homogenous red colour and is non-calciferous. It is described as a sand-clay-loam with 20% – 35% clay content.

Layout

This investigation was subdivided into two trials. Trial 1 consisted of a comparison of five *Cenchrus ciliaris* accessions (Molopo, Arusha, Makayuni, 409704 and Worcester) while Trial 2 consisted of a fertilisation trial on a pure stand of the cultivar Molopo and observations on the diet selected by sheep grazing Molopo foggage.

Trial 1

The area on which this trial was conducted, consisted of 20 plots (each 4m x10m with the grass established in rows) on which the five accessions were replicated four times in a randomized block design and layout. The trial received a standard fertilisation at the end of January 2000 of 100 kg N/ha in the form of limestone ammonium nitrate (LAN). Soil analyses indicated that there was no shortage of phosphorus (P) or potassium (K).

Trial 2

(a) The comparison of four fertiliser levels was conducted on 16 plots (8m x 5m) laid out in a randomized block design with four replications. The area used was level and homogenous in terms of both soil and topography. Effects of these factors could, therefore, be discounted and differences in terms of production and quality could, therefore, be ascribed to fertiliser effects. This area had been established several years prior to the commencement of this trial.

The experimental area were mown in January 2000 and then fertilised with 0, 50, 100 and 150 kg N/ha in the form of LAN. There were no shortages of phosphorus (P) and potassium (K), as indicated by soil analyses. This area was situated next to trial (b) where sheep were allowed to graze to determine the effect of grazing on the quality of available foggage from the early winter to late winter.

- (b) Two large camps (90m x 37m = 3330 m²) of Molopo buffelgrass were fertilised with a standard 100kg N/ha in January 2000 to accommodate a grazing trial with sheep which compared the quality of material selected by sheep with the clipped material from the small plot trial.

Collection of data

Trial 1

Foggage production, or pasture availability, was determined:

- (a) in late-summer (middle of March), when the production was determined by clipping 1m² quadrats of replications I & II, to determine quantity, quality and structure (leaf : stem). Afterwards the material on these two replications was mowed to generate new growth;
- (b) in autumn (end of April), on replications III and IV, when the pasture availability was again determined and the material was again mowed afterwards, and
- (c) in winter (end of June), when the entire sampling and processing procedure

was repeated on all four replications to again evaluate the foggage value of the pasture as determined from the average regrowth from all four replications I and II. (see Table 1)

Pasture quality of clipped samples (in terms of crude protein (CP) and *in vitro* digestibility (*in vitro* digestible organic matter - IVDOM), was determined for both leaf and stem components in autumn and winter. Crude protein was calculated (% N x 6.25) after % N was determined using the Kjeldahl technique (AOAC 1995), while the *in vitro* digestibility of organic matter (OM) was determined using the technique as described by Tilley & Terry (1963) as modified by Engels *et al.* (1981).

Trial 2

(a) Plant based observations

Pasture availability on the grazing camps was determined:

- (i) in late-summer (from clean cut to the beginning of March), when the production in the first part of the growing season was determined by clipping quadrats (1m²) in each paddock, prior to being mown and fertilised;
- (ii) in autumn (from clean cut to end of April), when the standing crop in terms of DM yield and leaf / stem ratio's was determined on similar quadrats to describe the pasture prior to the commencement of winter grazing;
- (iii) in early winter (from clean cut to the end of May) with the same procedure as

the above mentioned was followed except with grazing allowed and (iv) in late winter (middle of July), when the residue after winter grazing was assessed, in terms of residue and leaf / stem ratio's, on clipped quadrats in each paddock.

Pasture quality (of clipped samples) in terms of crude protein (CP) and *in vitro* digestibility (IVDOM), was determined for both leaf and stem components in summer, autumn and winter. Crude protein was calculated ($\% N \times 6.25$) after $\% N$ was determined using the Kjeldahl technique (AOAC 1995), while *in vitro* digestibility of OM was determined using the technique of *in vitro* fermentation as described by (Tilley and Terry 1963 as modified by Engels *et al.* 1981).

(b) Animal based observations

The pasture, which was stockpiled in the late summer, was grazed (as foggage) from 2 May 2000 to the beginning of July 2000. Grazing was by sheep stocked according to the availability of feed, to ensure that comparable grazing pressures (amount of feed / animal unit) were applied on the pastures. A standard drenching and inoculation program to eliminate parasites or diseases as confounding factors was followed. No mineral, protein or energy supplementation was provided.

After a two-week adaptation period (necessitated by the fact that the sheep had been on a milled, stall-fed ration prior to being placed in the experimental pastures) the trial period started. At each of the clipping dates two oesophageal

fistulated sheep were also used to obtain samples of material selected by the grazing animal. The following procedures were followed in the collection of these samples: the fistulated sheep were placed in the designated paddock for \pm 2 hours together with other sheep, then fistula samples were collected, the excess moisture was squeezed out, the samples were then placed in bags to be freeze-dried and milled. These samples were then analysed for IVDOM using the procedures already described. At the same time as fistula samples were collected, clipped samples (to try and simulate animal selection) were also collected and analysed for comparative purposes.

Analysis of data

An analysis of variance with the Proc-GLM model (SAS 1996) was used to determine differences between treatments. Least Square Difference (LSD) was used and the level of significance was tested with the Bonferroni test (Samuels 1989).

Results and Discussions

Trial 1

Availability of forage

The forage value comparison of these five accessions will provide farmers and extension officers with results - on production potential and quality attributes - to

make a decision on what cultivar to use. Molopo is one of the best known and most frequently used cultivars of *C. ciliaris* in South Africa. For this reason it is often used as a comparative standard and is, therefore, used for the same purpose in this trial.

Table 1 The dry matter availability (t DM/ha) of the five accessions as measured in late-summer, autumn and winter

Species	Season		
	Late-summer (Rep I & II)	Autumn (Rep III & IV)	Winter (Ave. of regrowth Rep I – II)
Molopo	8.5 ^c	13.0 ^m	3.2 ^y
Arusha	7.8 ^b	10.8 ⁿ	2.2 ^x
Makayuni	5.1 ^a	10.0 ⁿ	2.5 ^{xy}
409704	7.7 ^b	13.1 ^m	2.4 ^{xy}
Worcester	5.4 ^a	7.7 ^o	2.2 ^x

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Molopo and 409704 had consistently higher yields in late summer and autumn, with the regrowth indicating that Molopo was still the highest yielding cultivar. Arusha was also above average in terms of autumn yields and depending on adaptability, it might be a proposition in certain areas. The average regrowth from

autumn to winter did not differ significantly between the cultivars. This indicates that the best foggage yields are obtained when the pasture is rested. It was also an average rainfall season with an unfavourable distribution, and this could have influenced the performance of some accessions. Although *C. ciliaris* is known for its' drought tolerance, earlier work by Boshoff (1998) demonstrated that such accessions differ with respect to seasonal growth patterns.

% Leaf in available forage

Table 2 The % leaf in the five accessions sampled in late-summer, autumn and winter

Species	Season		
	Late-summer	Autumn	Winter
Molopo	66% ^b	63% ^y	33% ^m
Arusha	60% ^a	55% ^x	44% ⁿ
Makayuni	65% ^b	60% ^y	41% ⁿ
409704	68% ^b	64% ^y	33% ^m
Worcester	67% ^b	63% ^y	38% ^{mn}
Average	65%	61%	38%

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Except for Arusha, all the cultivars were very similar with respect to the % leaf produced in the growing months (Table 2). In mid-summer and autumn there was a lower leaf availability on Arusha, while in winter this accession had the most leaf. Makayuni, which also had the lowest yield in autumn (see Table 1) was, therefore, not very competitive at this stage. Worcester and 409704 compared favourably with Molopo with respect to % leaf, although the yield of Worcester was disappointing.

Quality of forage

Worcester had the highest crude protein (CP) content in late-summer, autumn and winter, although Molopo was a close second (see Table 3). It is important to have a high % CP in autumn / winter if an accession is to be considered suitable for foggage production. Worcester was, therefore, the best in this respect.

Table 3 The percentage crude protein (% CP) of whole plant material of the five accessions sampled in late-summer, autumn and winter

Age and structure	Late-Summer	Autumn	Winter
Molopo	8.1% ^a	5.7% ⁿ	3.4% ^x
Arusha	8.4% ^a	4.2% ^m	2.8% ^x
Makayuni	6.8% ^a	4.0% ^m	3.3% ^x
409704	7.1% ^a	4.5% ^m	3.1% ^x
Worcester	9.4% ^b	5.7% ⁿ	3.9% ^y
Average	8.0%	4.8%	3.3%

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

The leaf digestibility (Table 4) of Worcester was of the best in summer and autumn although there were minimal differences between accessions in the winter. Makayuni was the best in terms of stem digestibility (Table 4). As the digestibility of the five accessions were very similar and the percentage leaf also did not vary much, it is difficult to identify the best accessions. Worcester, however, had the best CP content and could, therefore, be most strongly recommended in terms of plant based qualities, although 409704 had the best digestibility of both leaf and stem.

Table 4 The *in vitro* digestibility (%) of the components of the five accessions sampled in late-summer, autumn and winter.

Age and structure	Late-summer	Autumn	Winter
(Leaves)			
Molopo	53% ^a	47% ^{mn}	32% ^x
Arusha	54% ^a	42% ^m	30% ^x
Makayuni	60% ^b	39% ^m	35% ^y
409704	58% ^b	45% ^{mn}	37% ^y
Worcester	61% ^b	51% ⁿ	32% ^x
Average	57%	45%	33%
(Stems)			
Molopo	42% ^a	35% ^m	28% ^x
Arusha	51% ^b	32% ^m	29% ^x
Makayuni	49% ^b	43% ⁿ	30% ^x
409704	50% ^b	37% ^{mn}	34% ^x
Worcester	44% ^a	36% ^m	31% ^a
Average	47%	37%	30%

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Trial 2

Availability of forage

Table 5 The dry matter availability (t DM/ha) of Molopo as measured in late-summer, autumn and winter at the different N-levels

Species	Season			
	Late-Summer	Autumn	Early-Winter	End-Winter
0kg N/ha	4.6 ^a	5.3 ^m	3.5 ^p	3.1 ^x
50kg N/ha	8.5 ^{ab}	8.1 ^{mn}	3.9 ^p	3.5 ^{xy}
100kg N/ha	13.1 ^b	11.9 ⁿ	5.6 ^q	3.8 ^y
150kg N/ha	13.0 ^b	12.5 ⁿ	6.2 ^q	4.0 ^y

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

In each of the different sampling periods, there was a marked increase in dry matter yield in response to level of fertilisation (Literature Review). This was most marked up to 100 kg N/ha. The increase from 100 kg N/ha to 150 kg N/ha was considerably less than and 100kg N/ha would be the recommended application rate with the current high fertiliser input costs. The slight decline in availability from late summer to autumn, reflected in Table 5, might be ascribed to early senescence.

% Leaf in available forage

The percentage leaf remained nearly the same from late-summer to autumn, but there was a significant decline from autumn to winter which can only be ascribed to winter senescence (Table 6). There was a definite positive influence of the higher fertilisation levels that was especially true in summer, but also throughout the season. Although the influence on % leaf from 100 kg N/ha to 150 kg N/ha was not as big as from 0 kg N/ha to 50 kg N/ha, it was still considerable. From Table 4 it was also evident that there was a steady decline in the % leaf as plants became more mature with a steep decline in winter.

Table 6 The % leaf in Molopo sampled in late-summer, autumn and winter as influenced by the different N-levels

Species	Season			
	Late-Summer	Autumn	Early-Winter	Late-Winter
0kg N/ha	55 % ^a	54 % ^m	38 % ^p	30 % ^x
50kg N/ha	61 % ^b	60 % ⁿ	42 % ^{pq}	34 % ^x
100kg N/ha	68 % ^c	62 % ⁿ	44 % ^{pq}	41 % ^y
150kg N/ha	66 % ^c	64 % ^{no}	46 % ^r	39 % ^y

Values in columns with the same superscript do not differ significantly. Significant differences were determined using a standard t-test where a P-value <0.05 indicated significance.

Quality of forage

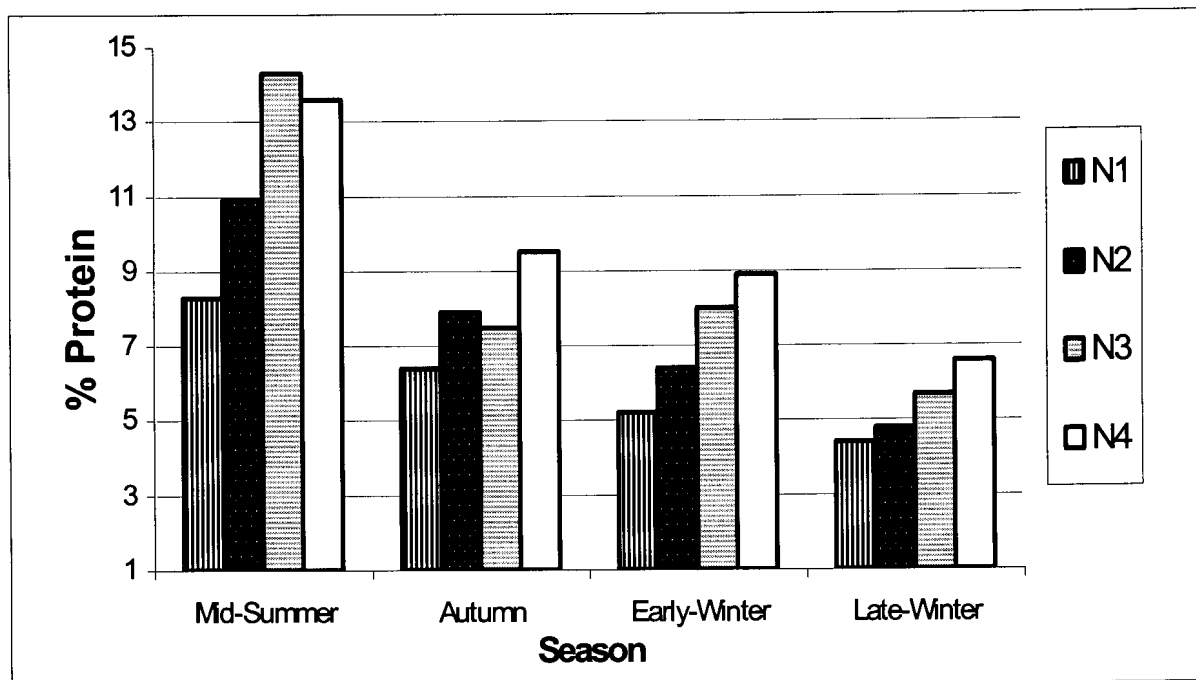


Figure 1 The percentage crude protein (% CP) of Molopo leaves from clipped samples in mid-summer, autumn, early-winter and late-winter.

As expected, the percentage crude protein of Molopo increased with higher N application rates. Although the N3 treatment (100 kg N/ha) outperformed the N4 treatment (150 kg N/ha) in the late-summer, the benefit of the higher fertiliser rate was evident at all other sampling times. The question is whether the farmer could justify more N. This can only be decided on a cost : benefit basis and the

farmers' need for a higher quality product at different times of the year. If the farmer is primarily interested in autumn or winter quality, a higher N application would be a serious consideration.

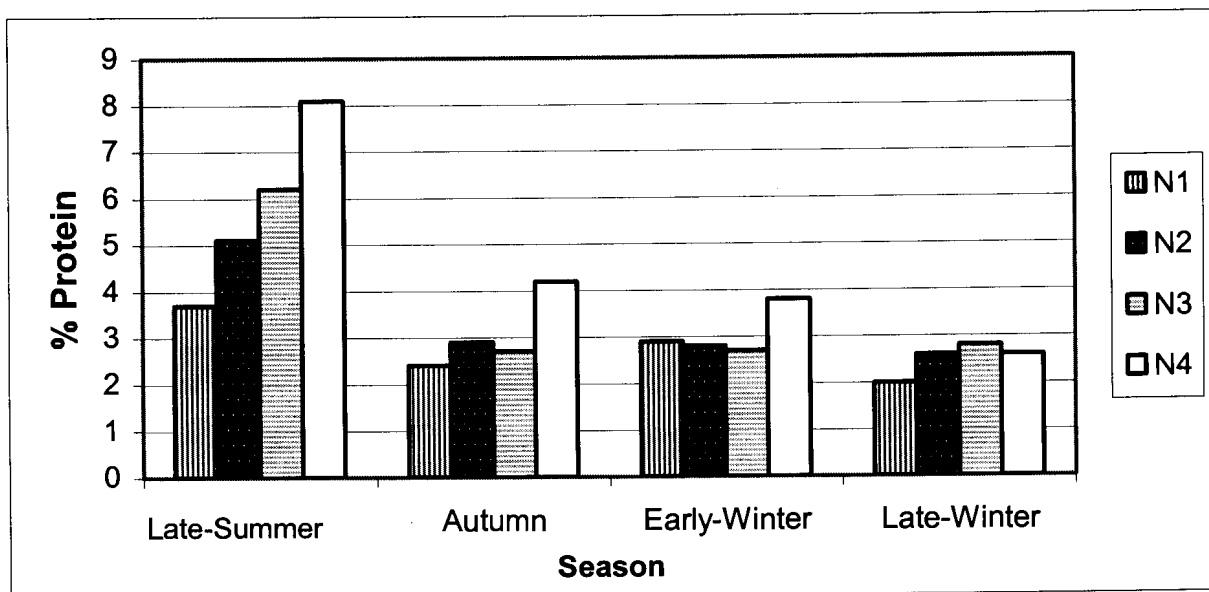


Figure 2 The percentage crude protein (% CP) of Molopo stems from clipped samples in late-summer, autumn, early-winter and late-winter.

It is evident from Figure 2 that the CP content of stem material was considerably less than that of leaves, but the higher rates of application (150 kg N/ha) had the highest CP content in the summer, autumn and early-winter. As this trial was

conducted to measure the foggage quality and thus the winter quality of the species used, the effect of fertiliser weren't as impressive in the stems as in the leaves. But as the leaves are more digestible in winter, the increased fertilisation practice will have an improved effect on the foggage quality.

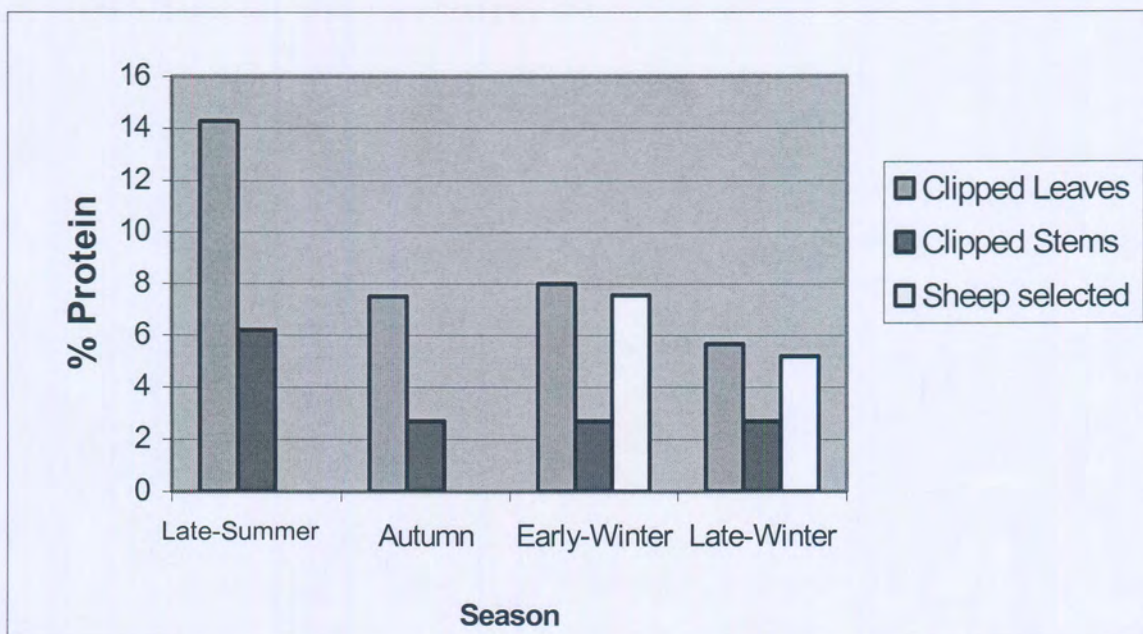


Figure 3 The percentage crude protein (% CP) of animal selected material in comparison with clipped Molopo samples (100 kg N/ha) in late-summer, autumn, early-winter and late-winter.

When grazed in the winter the sheep selected material had the same or even

slightly better crude protein content than the clipped leaves. This indicates that the sheep selected the best quality from the available pasture and demonstrates the value of a higher % leaf in accessions.

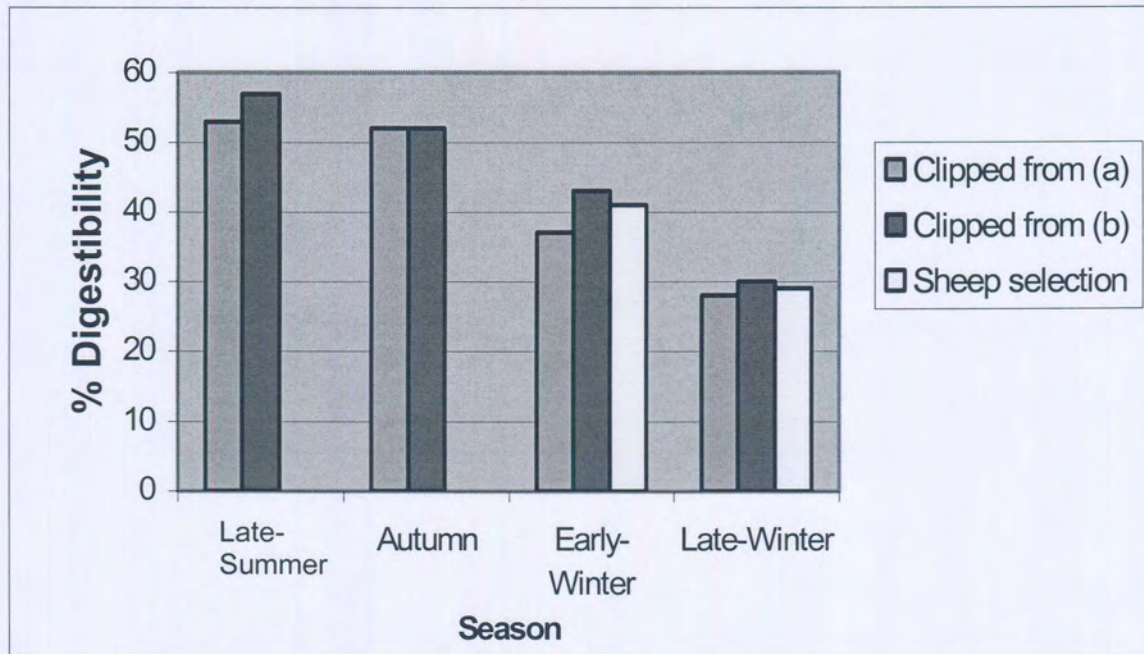


Figure 4 The *in vitro* digestibility (%) of material selected by grazing animals (100 kg N/ha) in comparison with that of clipped Molopo samples from the same camps (trial (b), 100 kg N/ha fertilized) and small plot trial of N3 (trial (a) 100 kg N/ha) in late-summer, autumn, early-winter and late-winter.

The digestibility of clipped material from trial (a) and trial (b) did not differ markedly from each other at each sampling date. The material selected by grazing sheep had a similar quality to clipped samples. This could be attributed (at least in part) to animals being able to freely select from the material on offer. From autumn onwards, however, the quality of the available and selected material declined.

Conclusions

From the comparison of the five accessions in trial 1, it may be concluded that there were only small differences between the accessions. Molopo and 409704 had the best summer yields, with Molopo the best in autumn. Except for Arusha, all the accessions were very similar with respect to the % leaf in the growing months. Arusha was, however, relatively disappointing in terms of the quality of material. The % leaf on Worcester and 409704 compared favourably with that on Molopo, although the yield from Worcester was disappointing. Arusha did not perform as well as had been expected (on the basis of earlier research), especially in terms of the quality of foggage. The leaf digestibility and CP content of Worcester was especially commendable, but Molopo was still one of the best cultivars available to the farmer. Molopo was a, therefore, good choice to use in trial 2 which placed the emphasis on fertiliser management (N levels) and animal based observations.

The N fertiliser applied to Molopo had a definite beneficial effect on both quantity and quality of material produced. The response from 100 kg N/ha to 150 kg N/ha was less than the responses from 0 to 50 kg N or from 50 to 100kg N/ha. 100 kg N/ha, therefore, is recommended in the light of the high current fertiliser input costs. The benefit of a high fertilisation treatment on Molopo is obvious from the results obtained, especially considering the improvement in quality. The samples gathered from grazing animals demonstrated that sheep always select a quality which was as high if not higher than that of the available leaf material, provided grazing pressures were light. It is very important to meet the needs of the animal and to manage the farm system according to that objective. From trial 1 it is concluded that different accessions may be used on different farms. The best adapted cultivar / accession in a specific area would be the choice as quality differences between accessions were small and variable. Molopo performed very well under local conditions and should always be considered, but the quality available in autumn and winter is of utmost importance and will be determined primarily by management to maximize the % leaf and the level of N-fertilisation. The farmer must balance input costs against animal needs when deciding on the level of fertilisation. A minimum of 100 kg N/ha is advised, but for higher producing animals, an even higher application rate might be considered.

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Chapter 6

General conclusions and recommendations on foggage production

How foggage fits into South African Agriculture

The use of foggage as winter feed for animal maintenance is unlikely to totally replace hay and/or silage, but should be used as an alternative for the early winter. Using foggage can also minimize expensive inputs, such as labour and machinery. This is the single most outstanding advantage of using pasture foggage over hay, haylage, crop residues or silage. Although pastures also have establishment and fertiliser costs, these are less than costs associated with intensive annual crops. Many pastures are also perennial, which means less establishment costs. This emphasizes the importance for less intensive farming systems. A significant proportion of soils used for crop production in South Africa, are classified as marginal. When these marginal soils are commercially farmed with annual crops, erosion is aggravated by excessive tillage, resulting in poor crop yields and quality. The crops used are often totally unsuited to such soils. Although the use of pastures on marginal soils is not a new concept, they offer farmers, who seek stable alternatives to risky crop production, a viable alternative. The agricultural economy especially is struggling because of declining margins between input costs and product prices.

About 13% of South Africa's surface area can be used for crop production. High potential arable land comprises only 22% of the total arable land. The rest can be classified as marginal soils and shows the potential for less intensive farming systems including perennial foggage crops. The most important factor limiting agricultural production is the low rainfall. Rainfall is distributed unevenly across the country, with humid, subtropical conditions occurring in the east and dry, desert conditions in the west. Only 10% of the total area receives an annual precipitation of more than 750mm. Because rainfall is extremely variable it is often stated that South Africa has a limited agricultural potential. Even in areas where information is still lacking, South Africa has the infrastructure to address these problems and find solutions. Agricultural land in South Africa is mainly used for grazing and foggage has, therefore, a large potential in assisting our farmers to supplement deficiencies in such grazing.

Quantity of foggage

Depending on what the objectives of the farmer are, he can manage foggage to produce a high yield with a lower quality or *vice versa*. Thus it is critical to maintain a balance between yield and quality. This balance was evident when the production of Silk was significantly better on the older pastures in both the early and late growing season. Whilst the early growing season growth could be used for grazing, hay or silage – dependent on the needs of the farmer – the late season growth was utilised as foggage / standing hay in the winter.

With the comparison between Smutsfinger grass, KII and Creeping finger grass it was noticed that Smutsfinger grass produced a fair amount of leaf material. It was, however, less than that of KII (which had the best yields together with Silk sorghum recorded in all the trials) because of its bunch growth form and a high tiller production. P66 also had a higher leaf material yield than Smutsfinger grass. KII had the best yield of the three pastures, with P66 also impressive in the late summer. Smutsfinger grass had the lowest % leaf throughout the trial, but due to its high acceptability for animals it had a low residue after winter grazing.

From the third trial, with Smutsfinger grass (*Digitaria eriantha*), Kleingrass (*Panicum coloratum*), Guinea grass (*Panicum maximum*) and Purple plume grass (*Bothriochloa bladonii*), it was evident that the first three species are all good choices for utilisation as foggage. In comparative terms, Guinea grass had the most material available, but had the lowest proportion of leaf material. If *P. maximum* is properly managed, it is undoubtedly the highest producing of the three species. But it lacks the resilience and persistence of Purple plume grass (*B. bladonii*) and Kleingrass (*P. coloratum*). It would seem that *D. eriantha* also needs high management skills whereas *B. bladonii* seems to be the least affected by management. But *Bothriochloa* species are, however, known to be less palatable, due to high concentrations of aromatic compounds. A grazing trial would be, therefore, recommended to evaluate *B. bladonii* in terms of palatability and animal performance relative to other species.

When comparing *Cenchrus ciliaris* accessions, Molopo and 409704 had consistently higher yields in summer and autumn, with the regrowth indicating

that Molopo was still the highest yielding cultivar. Arusha was also above average in terms of autumn yields and depending on adaptability, it might be a proposition in certain areas. The average regrowth from autumn to winter did not differ much between the accessions. This indicates that the best foggage yields are obtained when the pasture is rested for longer periods. Worcester and 409704 compared favourably with Molopo with respect to % leaf, although the yield of Worcester was disappointing.

With the fertilisation trial on Molopo, there was a marked increase in dry matter yield as the N levels were increased from 0 kg N to 100 kg N/ha. The increase from 100 kg N/ha to 150 kg N/ha was considerably less and 100kg N/ha would be the recommended application with the current high fertiliser input costs. The slight decline in availability from late summer to autumn, might be ascribed to early senescence. The percentage leaf remained nearly the same from late-summer to autumn, but there was a drastic decline from autumn to winter. Although the influence on % leaf from 100 kg N/ha to 150 kg N/ha was not as big as from 0 kg N/ha to 50 kg N/ha, it still had a considerable effect.

Quality of foggage

As with the yield, the quality is strongly influenced by the closing-up time. Foggage quality was inversely related to the growing season after the pasture was closed-up and thus the quality will be lower with earlier closing-up time.

Fertilisation, especially with nitrogen, will increase the crude protein of the product (6% - 12%CP).

It was evident from all the trials that young, leafy material and higher fertilised material all contributed to a higher quality especially in terms of CP. Sheep selections always had a high quality and demonstrated the ability of the animals to select according to their needs, if quality material is provided. It was concluded that Smutsfinger grass and Guinea grass had the best CP content as foggage and would thus be the best species to use where it is well adapted.

The *in vitro* digestibility of Silk declined from autumn to late winter with a bigger difference in the digestibility of stem material between the different ages of pastures. Smutsfinger grass outperformed Kll and P66 in terms of digestibility and would thus be the first choice for maintaining animals through winter. It seems that Purple plume grass also has a good *in vitro* digestibility, but because of a possible aromatic compound content, it might not be as acceptable for animals and hence the need for a grazing trial on Purple plume grass.

Molopo performed very well under local conditions and should always be considered, but the quality available in autumn and winter is of utmost importance and will be determined primarily by management, to maximize the %leaf, and the level of N-fertilisation. The farmer needs to balance input costs against animal needs when deciding on the level of N fertilisation. A minimum of 100 kg N/ha is advised, but for higher producing animals, an even higher application rate might be considered.

Utilisation of foggage

The most important objective in producing foggage, is to feed animals to at least maintain body weight through the winter season. As foggage is generally not a high quality feed, it usually can not be used for producing animals without supplementation. It is often necessary to make provision for an adaptation period. This often results in an initial decline in body weight as the intake of such material may be low for a period of time. After this adaptation period intake improves but utilisation can result in trampling and waste. It is, therefore, often recommended that grazing management in the form of high utilization (HUG) must be implemented to use the foggage to its full potential.

Sheep grazed the one-year-old Silk pasture more readily at the beginning of the trial period (didn't need the adaptation period), but by the end of winter there was very little difference between pastures of different ages. Silk was noticeably more acceptable for the animals when they were introduced at first in comparison to all of the other grazed foggages. Smutsfinger had a high acceptability for animals and, therefore, it had a low residue after winter grazing. There weren't any noticeable differences between Smutsfinger grass, Kleingrass and Guinea grass in relation to palatability. As mentioned earlier, the palatability of Purple plume grass must still be studied.

Unfortunately a grazing trial on the five *C. ciliaris* accessions wasn't possible and it is, therefore, difficult to say which accession is the most palatable. Worcester, however, had the best CP content and could, therefore, be most strongly recommended in terms of plant based qualities, although 409704 had the best

digestibility of both leaf and stem. Fortunately it was very evident from the fertilisation trial on Molopo that higher fertilised areas are much more palatable as the sheep grazed it first down. It is, however, again the farmers' decision to balance input costs against animal requirements when deciding on the level of fertilisation which has a very definite effect.

Recommendation

Agriculture in South Africa is very dependant on its' farmers to keep this part of the economy successful. It is, therefore, very important to get results like these through to our farmers in need, especially when expecting a drought season.

The aim of this study was to determine which pasture provided the best foggage in different scenarios. The conclusion is, therefore, that a farmer must firstly decide on his management plan and where his foggage will fit in. Then it is recommended to choose the species (or accessions) that are best adapted to the specific area of farming.

Silk sorghum and Coastcross II had the best yields recorded. Smutsfinger grass was very palatable, had high digestibility and would, therefore, be recommended for quality in the higher rainfall eastern parts of the country. Because of its' drought resistance, Molopo and Kleingrass will be recommended for the dryer areas with less rainfall and Molopo especially for small farmers who lack overall grazing management skills.