THE EFFECT OF PLANTING DATE ON THE GROWTH POTENTIAL OF DIFFERENT FORAGE SORGHUM CULTIVARS.

A MINI-DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF MASTER OF SCIENCE
(PASTURE SCIENCE)

BY

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DECLARATION

I Lesego Minah Bodibe hereby declare that this thesis submitted by me for the Master of Agriculture in Pasture Science degree at the University of Limpopo comprises of my own original work and investigation. Work by other authors, which served as sources of information, has duly been acknowledged by way of in-text referencing and bibliography. I furthermore declare that it has neither wholly nor partially been presented as dissertation for the degree at any University.

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ABSTRACT

Forage sorghum is widely grown in South Africa as annual summer forage to supplement pasture production for sheep, beef and dairy cattle. A number of sorghum cultivars are available commercially, and periodically some cultivars are added while others are withdrawn from the market. The potential yield figures and the nutritive value of these forage sorghum cultivars are generally not known.

The management practices that improve forage sorghum production and quality include the time of planting and time of harvesting. The genetic makeup of different forage sorghum cultivars also accounted for a portion of the production and quality.

A field experiment was conducted at Dewageningsdrift Experimental Farm (DWD), Moloto, Gauteng and Nooitgedacht Agricultural Development Center (NGD), Ermelo, Mpumalanga to study the influence of planting date on the growth potential of different forage sorghum cultivars. Three planting dates were used: mid-December 2006, mid-January 2007 and mid-February 2007. Thirteen different cultivars were incorporated in the trial to evaluate influence of the breeding history. The cultivars were defoliated at three different stages: cut repeatedly at six weekly intervals (Dt 1), cut repeatedly when it reached a grazing stage (± 800 mm high) (Dt 2) and once at the silage stage (soft dough) (Dt 3).

At DWD the average total dry matter (TDM) productions, for the six week cutting treatment (Dt 1), were 10760 kg/ha, 5195 kg/ha and 1944 kg/ha for December, January and February planting date respectively. For the same treatment, at NGT, the average TDM productions were 6396 kg/ha and 1737 kg/ha for December and January respectively. The February planting resulted in the poor germination and seedling emergency. The seedlings did not survive due to low temperatures. The minimum of 13 ºC and 11.8 ºC as well as the maximum of 24.1 ºC and 23.0 ºC in February and March were below the required germination temperature (15 ºC). The highest producers that is available in the market were Jumbo, Sentop, Piper, Kow Kandy, and Sugargraze.

Defoliated repeatedly at grazing stage (Dt 2), at DWD, resulted in average TDM productions of 8541 kg/ha, 4950 kg/ha and 2683 kg/ha for December, January and February, respectively. At NGT the average TDM productions were 7769 kg/ha and 3010 kg/ha for December and January respectively. The highest producers were Jumbo, Kow Kandy, Piper, Sentop and Sugargraze.

The average TDM productions at the silage stage (Dt 3), at DWD, were 17923 kg/ha, 15015 kg/ha and 2529 kg/ha for December, January and February respectively. At NGT the average TDM production was 11856 kg/ha and 5350 kg/ha for December and January, The highest producers were Jumbo, Sugargraze, Kow Kandy, Sentop and Kow Kandy.

December planting proved to be the best planting date for optimum DM production, compared to later plantings in January and February.

Keywords

Forage sorghum, cultivars, planting dates, defoliation stages, grazing stage, silage

LIST OF ABBREVIATIONS

DWD	Dewagenings Drift Experimental Farm
NGT	Nooitgedacht Agricultural Research Station
ARC	Agricultural Research Council
ISCW	Institute for Soil, Climate and Water
PD 1	December 2006
PD 1	January 2007
PD 3	February 2007
LTA	Long term average
Cv	Cultivars
Cut	Cutting date
Cut 1	First cutting treatment (for cutting 6 weekly, at the grazing stage and silage stage)
Cut 2	Second cut for season
Cut 3	Third cut for season
Cut 4	Fourth cut for season
Dt	Defoliation treatment
Dt 1	Six weekly cutting treatment
Dt 2	Defoliated at the grazing stage (± 800 mm high)
Dt 3	Defoliated at silage stage
DM production	Dry matter production
TDM	Total dry matter production
Cv X Dt	Cultivar X Defoliation treatment interaction
CV%	Coefficient of variation
LSD	Least significant difference
ADF	Acid detergent Fibre
NDF	Neutral detergent Fibre
CP	Crude protein

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Agriculture remains one of the cornerstones of the South African economy, with the country's economic performance often reflecting the state of agricultural conditions (Engelbrecht and Kirkman 2004). According to Van Zyl (2006) livestock production, mainly sheep and beef in the Mpumalanga Highveld, forms an important component of the agricultural economy of the region and depends to a great extent on veld as a source of feed.

Rangelands (veld) play an important role in the economics of animal production, as it is a key element in the provision of cheap feed for the livestock industry in South Africa. For the majority of the emerging farming communities, veld remains the main and the cheapest source of fodder. The sustainability of livestock production systems is highly dependent on the effective utilization of veld, for short term benefit, whilst conserving it for future generations (Palmer and Ainslie 2002).

The greatest concern is that the condition of veld is deteriorating and the situation is being aggravated by low an unpredictable annual rainfall in most parts of South Africa. According to Aucamp and Danckwerts (1989), 60% of veld in South Africa is in a poor condition, while 30% is in a fair condition with only 10% in a good condition. Barnes (1992) reported similar figures for the eastern Highveld of Mpumalanga. The recovery of degraded veld, especially sour grass veld which dominates on the eastern Highveld, is extremely slow.

Schwalbach (2003) highlighted shortage of feed, particularly during the dry season, as one of the major reasons for poor beef production in South Africa. It is generally accepted that low nutritional value and acceptability of the herbage of the veld in the dormant season has a negative effect on growth and conception rates of livestock. This results in suboptimal production and reproduction and implies a negative impact on profitability of the livestock enterprise in the long term (Clatworthy 1998). The strategy for the enhancement of livestock production in South Africa should therefore be primarily on the increasing of fodder productivity both quantitatively and qualitatively through introduction of high yielding planted pasture species (Van Zyl 2006).

1.2 PROBLEM STATEMENT

The area of land available for agriculture is shrinking at an alarming rate due to a steady increase in other forms of land use, such as mining, industrial and urban development. It appears that there has been a decline in grazing lands over the past ten years in all provinces. Rapid urbanization is the main reason for this loss in Gauteng, while mining and commercial forest plantations are by far the greatest in Mpumalanga (Hoffman 1997).

Approximately 65% of the country is semi-arid, with only 28% of the country receiving more than 600 mm of rainfall per annum (Palmer and Ainslie 2002). Furthermore, a large proportion of the land used for annual crop production in South Africa is marginal, resulting in low and variable yields. Such lands are suitable for the establishment of planted pastures for improving animal production (Adler 1995).

According to Jones *et al*. (1989) and Mapiye *et al.* (2006), there are several alternative means by which fodder production can be raised from low natural veld levels to levels capable of supporting the necessary expansion of livestock number and convert low yielding annual crop lands to highly productive planted pasture lands. These alternatives includes introduction of improved planted pastures (grasses), legumes and fodder crops which are generally bulky, high yielding and have broad environmental adaptations.

The shift towards alternative fodder crops (planted pastures) necessitate the need for norms to be established for the production potential of both dry land and irrigated pastures, the incorporation of such pastures into suitable fodder flows and the economics of animal production from pastures. Without such norms, rational decisions with respect to movement towards planted pastures will not be possible (Kirkman 1992).

Planted pastures such as forage sorghum can be incorporated in the fodder flow program to relief the pressure from the veld. Forage sorghum is widely used as an alternative pasture to veld during summer, winter and spring for grazing, silage, green chop and hay (Dickenson *et al.* 1993). It has the potential of providing fodder five to six weeks after establishment. The incorporation of this alternative fodder crop in the fodder flow program would allow farmers to prolong the grazing season. It can help them to be more self-sufficient in home-grown fodder, resulting in less off-farm expenditure and potentially greater monetary returns for small and large production.

1.3 MOTIVATION OF THE STUDY

Since the veld has limited nutritive value, there is a need to supplement with improved forage species that can result in an increase in animal productivity, nutritive value and digestibility of the forage (Donaldson 2001). Forage sorghum has already proved itself as a valuable alternative fodder source to relief pressure on the veld as it can be utilised for grazing, silage, hay and green feed (Pannar 2006).

Due to the developing market for forage sorghum as an alternative fodder crop, especially in areas where water is a concern, several types of hybrids are of interest (Pannar 2006). A number of sorghum cultivars are available commercially. Periodically some are added while others are withdrawn from the market. The potential yield and the nutritive value of these forage sorghum cultivars are generally not known.

The lack of research based knowledge (scientific data) of agricultural practices such as correct planting date, the productivity (yield) of different cultivars at different utilisation stages and nutritive value of forage sorghum cultivars are not known. Farmers are therefore faced with the problem of deciding which sorghum cultivar is best suited for his needs (Donaldson 2001). This hinders the effective planning of alternative fodder sources because farmers will not be enable to take informed decisions on how to fit it in their fodder flow program. These gaps prompted this study and supplied the rationale for investigation.

1.4 AIM AND OBJECTIVES OF THE STUDY

1.4.1 Aim

The aim of this study was to investigate the role that high producing forage sorghum cultivars can play to provide solutions to overcome nutritional shortfalls in the fodder flow program for farmers in the medium to high rainfall areas of South Africa (Mpumalanga, Gauteng and Kwazulu-Natal).

1.4.2 Objectives

The main objectives were

1. To determine the effect of different planting dates on dry matter production and nutritional value of selected forage sorghum cultivars.
2. To determine the effect of different cutting stages on dry matter production and nutritional value of selected forage sorghum cultivars.
3. To determine the effects of interaction effects of different planting date and cutting stage on dry matter production and nutritional value of selected forage sorghum cultivars.

CHAPTER 2
LITERATURE REVIEW

2.1 CHARACTERISTICS OF SOURVELD AND ANIMAL PRODUCTION ON SOURVELD

Most livestock farmers in the medium to high rainfall areas of South Africa (Mpumalanga, Gauteng and Kwazulu-Natal) experience a nutritional shortfall during winter in their fodder flow program. According to Tainton (1999), the Mpumalanga Highveld, Gauteng and the northwestern parts of Kwazulu-Natal can be classified as sourveld, with its well-known nutritional shortfall in the dormant period. It is well documented that sourveld cannot maintain animal production for a full year (Engelbrecht and Kirkman 2004).

The term "sourveld" is sometimes controversial in certain schools of thought, but the definition of sourveld, according to Trollope and Trollope (1990) is as follows: "Sourveld is veld occurring at a high elevation, experiencing high rainfall and cold winters in which the forage plants become unacceptable and less nutritious on reaching maturity, thus allowing the veld to be utilized for only a portion of the year in the absence of licks".

According to Tainton (1999) the most difficult periods of the year for livestock in the semi-arid summer rainfall areas are late winter, spring and early summer, whereas in the medium to high rainfall (sourveld) area, the deficiency is in the late autumn and winter periods. The typical nutritional pattern of grasses in sourveld is that of high nutrition and high palatability of new growth during spring and early summer, after which there is a rapid decline to low nutrition and palatability in the late summer and autumn. After the first severe frost, the nutritional value of grasses is extremely low and few classes of livestock are not able to gain, or maintain mass, on this source of feed during winter (Engelbrecht and Kirkman 2004).

The conditions of grazing animals are at their best during the short wet season summer (where grasses grow and mature rapidly producing abundant biomass). With the onset of the dry season both quantity and quality of the pasture herbage decline and fail to meet the maintenance requirement of grazing animals. As a result animals go through cycles of weight gains in the wet summer months and weight losses in the dry seasons (Van Zyl 2006).

The nutritional inadequacy of quality fodder imposes a major constraint on sustainable livestock production and a critical limitation on profitable animal production under traditional systems where grazing constitutes the only source of feed for livestock. As the result of this, the use of alternative and/or additional fodder in the winter to increase the production of livestock enterprises becomes highly important (Engelbrecht and Kirkman 2004).

2.2 THE ROLE OF PLANTED PASTURES

In South Africa the most commonly grown annual subtropical grasses are *Eragrostis teff*, *Pennisetum glaucum* and *Sorghum* species. Planted pastures can supply strategic grazing in times when other sources of fodder are unavailable during late summer, winter and spring. The utilisation thereof can ease the grazing pressure on the veld to a large extend (Dannhauser 1991).

In reality, fodder production from planted pastures on a farming unit provides an increased carrying capacity and improves the fodder flow. They provide quality herbage that can be conserved in a form of hay, silage and foggage which can later be utilized when veld production is low or of poor quality. If planned and managed correctly they improve the performance of individual animals and hence, the profitability of the livestock enterprise (Jones *et al.* 1989). Introduction of planted pastures such as forage sorghum can be a solution by which the productivity and stability of animal production can be raised above the natural level by ensuring the availability of good quality feed on an annual basis (Dannhauser 1991).

2.3 FORAGE SORGHUM AS THE POTENTIAL SOLUTION

2.3.1 Origin and distribution of forage sorghum

According to Gerlach and Cottier (1974), it is considered that forage sorghum originated in Ethiopia and its main centre of distribution is in Africa. It has been cultivated in Ethiopia for more than 500 years. The cultivation of forage sorghum has spread to other parts of Africa, India, Southern Asia, Australia and the United States. Forage sorghum possibly also developed independently in India and China. It is now widely distributed throughout the tropics, subtropics and warm temperate areas of the world.

2.3.2 Morphological description

Forage sorghum an upright, summer growing, tufted crop which can grow from 0.5 m to 4 m tall and produces more vegetative growth and less seed. Under drought conditions, sorghum leaves tend to fold rather than roll, as done by maize leaves. A heavy white wax layer usually covers sorghum leaf blades and sheaths, protecting them against water loss under hot, dry conditions (Undersander *et al.*1990).

The roots of the forage sorghum plant are divided into a primary and secondary system. The primary roots are those which appear first from the germinating seed and they provide the seedling with water and nutrients from the soil. They have limited growth and their functions are soon taken over by the secondary roots. This permanent root system branches freely, both laterally and downwards into the soil. If no soil impediments occur, roots can reach a lateral distribution of 1 m and a depth of 1.5 m (www.tropicalforages.info).

The stem/stalk is solid, dry to succulent and produces an abundance of leaves. Under favourable conditions more internodes develop, together with leaves, producing a longer stem. The stem consists of internodes and nodes. A cross section of the stem appears oval or round. The diameter of the stem varies between 5 mm and 30 mm. The internodes are covered by a thick waxy layer, giving it a blue-white colour. The waxy layer reduces transpiration and increases the drought tolerance of the plants. The inflorescence of forage sorghum is a panicle. The shape and colour of the panicle varies between cultivars. The panicle is carried on the main stem by the peduncle. The peduncle is usually straight and its length varies from 75 mm to 500 mm.

Since this is a hardy and a good quality fodder crop, farmers have used it for both grazing and silage making in the medium to high rainfall areas of South Africa (Mpumalanga, Gauteng and Kwazulu-Natal). Forage sorghum has significantly less water requirements than maize grown for silage. This characteristic provides considerable flexibility for forage/livestock producers in managing their resources and responding to the critical needs of their livestock.

2.3.3 Forage sorghum genetics

In recent years forage sorghum has improved through extensive breeding efforts and selection of highly nutritious cultivars. The development of new cultivars aims to reduce risks and to improve the existing cultivars for better yields. Forage sorghum cultivars can vary considerably in yield potential, height, fodder quality and grain content. It is important to match the traits of the cultivar to the desired use of the crop. Cultivars differ in their reaction to the environment and the climate. Factors that must be taken into account when selecting cultivars are yield potential, adaptability with regard to climatic and soil conditions, utilization, ability to recover after utilization, palatability, nutritive value, prussic acid content and disease resistance (McKindlay and Wheeler 1998).

Gerlach and Cottier (1974), classified forage sorghum into three groups: sweet sorghum, sudan grass and sorghum X sudan grass hybrids. The most popular forage sorghum types currently grown are the so-called sorghum x Sudan grass hybrids which, as the name indicates, are crosses of inbred lines or selections of grain sorghums and Sudan grass to produce forage varieties with improved nutritive values and productivity (Kalton 1988). They include both older and newer versions of sorghum X sudan grass, late maturing types, brown midrib hybrids and photoperiod sensitive forms (Pannar 2006).

Sudan grass has been used extensively in the past, but has declined in popularity with the development of sorghum x Sudan hybrids. Sudan grass has a potential of quick regrowth after defoliation. As a result it was best used in multiple cut systems. Like Sudan grass, hybrids have the ability to regrow faster after grazing if growth is not limited by environmental factors. The breeding of sorghum x Sudan hybrids was intended to increase the cutting frequencies and adaptability of forage sorghum (McKindlay and Wheeler 1998).

Plant breeders have, over time, selected specific cultivars from the original genetically diverse species. More recently breeders started to incorporate the Brown Midrib (BMR) gene. This gene contains a visible marker which colours mainly the midrib of the leave to a brown colour, although other parts of the plant, like the stem, could also be coloured.

The presence of BMR is associated with the reduction of lignin in maize, sorghum and pearl millet, which leads to a higher digestibility. Lignin is the primary constituent that provides strength to the cell wall. It is the primary non-digestible component of forages – the higher the lignin percentage the lower the digestibility and quality. Brown Midrib sorghums have 40% to 60% less lignin compared to conventional sorghums. Significant increases in digestibility, palatability and efficiency are proven benefits of the BMR gene (www.altaseeds.com) / altaseeds@advantaus.com.

The most commonly used forage sorghum hybrids with their important characteristics are as follows and illustrated in more details in Table 2.1. [The forage book (ISBN 0959423117) – Pacific seeds Toowoomba, Queensland, Australia]

- Sudan x Sudan grass hybrids

These types are suitable for repeated, heavy grazing with excellent recovery between grazing cycles. The feed quality is often higher than that of Sudan grass x grain sorghum hybrids. These types are suited for hay making because they tiller heavily and have finer stems than other sorghums. They are lower in prussic acid than other forage sorghums, e.g. Superdan, PAC8288.

Table 2.1: Most commonly used forage sorghum cultivars in South Africa
[The forage book (ISBN 0959423117) – Pacific seeds Toowoomba, Queensland, Australia]

TYPE	CULTIVAR	IMPORTANT CHARACTISTICS	PRIMARY USE	SECONDRY USE	FLOWER
Sudan grass X Sudan grass	Superdan	Fine stem, prolific tillereing			Late
BMR sorghum X Sweet sorghum	Hygrosil	Broad leaves 1 – 2 X regrowth	Silage	Green chop, graze	Med 85 days
	BMR Silage Master	Highly palatable & digistable. Resitant to leave diseases	Silage		
Sweet sorghum X Sweet sorghum	Sugar-graze	High sugar Good standing hay Good grazing autumn	Standing hay	Graze, silage	Late
Sweet sorghum X Sudan grass	Nectar	Feb - April grazing 2-3 x regrowth (4x young cutting/grazing stage)	Graze	Standing hay	Late
Grain sorghum X Sudan grass	Kow Kandy	Early flowering. Thin stems. Drought resistant. 3 x regrowth cycles	Graze	Hay, silage, green chop	Quick
	Multicut	Drought resistant Ready within 3 – 6 weeks. Regrowth	Graze, hay	Silage, green chop.	
	Jumbo	Very leavy. Quick spring growth. Good autumn grazing	Grazing	Hay, silage (wrapped bales)	Late
	PAN 841	Prolific regrowth,every 5-6 weeks. Not for horses	Graze	Silage	
	PAN 888	Widely adapted, More resitant to leave disease than PAN841	Graze		
	Bulkmaster	Dual purpose. Long vegetative period	Silage	Green chop.	Late
BMR sorghum X Sudan grass	Hygro graze BMR	Broader leaves, Tillering. Photoperiod sensitive, stay long vegetative, high sugar	Graze	Hay, standing hay	Long 160 days
	Kow Kandy BMR Improve	Larger & broader leaves, medium stem size. High sugar content, low fiber, high digestibility	Graze,	Silage, standing hay, green chop.	Med 88 days
	BMR Grazer	Highly palatable & digestible	Graze	Standing hay	-
Grain sorghum X Sweet sorghum	Silage King	Sweet sorghum type with bird resistant seed	Silage		
Other hybrids	Sentop	High production Good regrowth High protein and digestibility			
	Senfor	Excellent production Good and quick regrowth High protein and digestibility Very palatable			

- Sweet sorghum x Sweet sorghum hybrids

These hybrids recover slowly after grazing (poor regrowth) and are characterized by thick stems, with a high sugar content. They are mainly used for stand-over feed for autumn and winter or for silage.

The preferred planting time is from December to January, e.g. Lahoma, Piper, SS.6, Sucro, Sugargraze, Hunnigreen, Megasweet.

- Sweet sorghum x Sudan grass hybrids

These hybrids are similar to sweet sorghums with high sugar contents, but are faster in regrowth, Bantu, Zulu, FS-22A, Sudax, Speedfeed, Jumbo, Lush.

- Perennial forage sorghums

The only cultivars available at the moment is Silk which is a short lived perennial, more suited to short term pasture rotations of 2 to 3 years.

➢ Rainfall

Forage sorghum performs best with an annual rainfall of more than 600 mm, but it can be successfully cultivated in areas a rainfall as low as 400 mm. Forage sorghum is able to tolerate drought better than most other grain crops because it possess xerophytic characteristics, physiological and morphological attributes that allow them to be resistant or tolerant to moisture stress (Miller and Stroup 2003). Forage sorghum has the ability to enter a so-called growth dormancy phase during periods of stress. Moisture consumption is curtailed and physiological development is retarded. According to Miller and Stroup (2004) and Peterson *et al.* (1982), this can be attributed to:

- An exceptionally well-developed and finely branched root system, which is very efficient in the absorption of water.
- A small leaf area per plant, which limits transpiration.
- Efficient leaf folding during warm, dry conditions.
- An effective transpiration ratio of 1:310. The plant uses only 310 parts of water to produce one part of dry matter, compared to a ratio of 1:400 for maize.
- A leaf epidermis that is corky and covered with a waxy layer, which protects the plant form desiccation.
- Rapidly closing stomata to limit water loss. During dry periods, sorghum has the ability to remain in a virtual dormant stage and resume growth as soon as conditions become favourable. Even though the main stem can die, side shoots can develop and form seed when the water supply improves.

However, after rain it recovers rapidly and compensates well for drought damage, by developing many leafy tillers. In areas with a high humidity and where misty weather is prevalent, it is not recommended as the conditions influences the development of diseases such as rust and ergot (Dickenson *et al.* 1993).

2.3.5 Soil requirements of forage sorghum

Forage sorghum do well on a large variety of sandy to clayey soils and can be planted more successfully on marginal soils than other crops, like maize (Donaldson 2001). It adapts well to soil with a pH of 4.5 to 5.5 (KCl) and is even tolerant to brackish conditions, to a certain extent. It is sensitive to aluminum toxicity and soils with acid saturation higher than 20% can pose a problem. Forage sorghum can produce high yields even on low fertility soils, but responds very well to good fertilization practices, especially nitrogen. It is essential that the crop is fertilized adequately in order to utilize its potential to the full and achieve high yields (Dickenson *et al.* 1993). Soils seriously infected with witchweed must be avoided (Pannar 2006).

2.3.6 Establishment of forage sorghum

The essential management practices to improve forage sorghum production and quality include the time of establishment and harvesting. Planting date seems to account for most of the yield variation whereas the genetic makeup of different forage sorghum cultivars in turn, account for a portion of the total variability. The planting date of forage sorghum is determined by the first spring rain, distribution of the seasonal rainfall, stored moisture in the soil profile, soil temperature, frost-free period and the cultivar to be planted.

With early planting soil temperature and sufficient water in the soil is important. Forage sorghum is sensitive to low soil temperatures. The ideal temperature for germination is 18°C or higher, while 25°C to 30°C is required for growth and development. Exceptionally high temperatures are suspected to reduce yield.

Establishment in December till February provides the highest yield, coupled with relatively late flowering and sustained quality (Donaldson 2001). Establishment at intervals during the period of December till February will result in a longer fodder flow program. For grazing purposes the sorghum X sudan cultivars may be planted early in December to allow three to four grazing cycles (Donaldson 2001).

With late plantings in March and April, the length of the remaining growing season seems to be a limiting factor because cool soil reduces seed germination and delays emergence. This planting date seems to yield low total dry matter production due to short plants. Late planting might not allow the crop to reach the optimum cutting stage before frost in areas such as Mpumalanga. Generally planting dates should be scheduled to overcome the variable environmental factors in the area concerned (Fair 1989).

The differences among cultivars have the great influences on the planting date. Cultivars with long growing season are usually planted earlier than those with a short growing season. Cultivars with different growing seasons can be planted at different planting dates so that the risk of extreme weather conditions is reduced and the availability of fodder is prolonged.

Establishment of forage sorghum is relatively easy. A firm moist, weed free seed bed is extremely important. The planting depth varies between 3 cm and 5 cm (Pannar 2006). Sowing density is determined by the soil type and the expected rains. Planting in rows is usually advocated for dryland and the drier the area, the wider the spacing. Sowing density is 7 kg to 10 kg seed/ha in rows or 15 kg to 25 kg seed/ha when broadcast (Donaldson 2001).

2.3.7 Fertilization of forage sorghum

Fertilization is important for optimal production. The quantity of fertilizer applied at planting, is determined by the fertility level of the soil (as per soil analysis) as well as the yield potential. The Phosphorus level of the soil should be approximately 15 mg/kg. As a guide, nitrogen should be applied at a rate of 15 kg N/ha at planting. After each grazing cycle a topdressing of nitrogen should be given. Quantities will depend on the expected yield as determined by rainfall and soil. One or two topdressings of 30 to 50 kg N/ha each, should be adequate. Potassium is seldom needed if the crop is grazed. If silage is produced and the potassium level of subsoil, topsoil, or both is lower than 80 mg/kg, potassium must be supplemented (Dickenson *et al.* 1993).

2.3.8 Forage quality and nutritive value

Forage quality refers to how well animals consume a forage and how efficiently the nutrients in the forage are converted to meet animal requirements for production and maintenance (Buxton 1996). Specific levels of forage quality are required for different classes of livestock, seasons and conditions. The nutritive value of pastures follows a seasonal pattern, as exemplified by protein, which reaches a maximum level in the rainy season and a minimum concentration during the dry season (Du Toit *et al.* 1940).

According to Fick and Mueller (1989) the crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) are parameters for considering the suitability of the forage (quality). The CP content in plants is influenced by the type of species grown, management practices and the maturity at harvest (Humphreys 2005). When the forage sorghum plants are young and growing rapidly, CP content may be 20%, but as they increase in height and near maturity, it declines to 7% or less (Leep 2005). Yosef *et al.* (2009) reported that the CP content of forage sorghum harvested at the soft dough stage ranged between 7% and 9%.

When the CP content of a pasture is above 13% beef cattle can maintain animal weight. Above 18% animals will gain weight. However, if the level of CP in herbage declines to below 6% to 8% appetite is depressed and the herbage intake declines (Minson and Milford 1967; Dannhauser 1991) due to a slower rate of fibre digestion (Waldo 1970; Weston and Hogan 1973).

According to Tainton (1999) ADF represents mainly the cell wall (fibrous) components of the plant material and includes cellulose, hemicellulose, lignin, cutin, silica and tannins. The lower the lignin content, the more of the ADF fraction is digestible and the higher the energy content of the forage (Bean and McCollum 2006). As ADF increases, digestibility of forage usually decreases. Blezinger (1999) quoted an ADF % of between 31% and 40% as good to very good quality. When it ranges between 41% and 42% it can be described as medium quality and when higher than 42% as low quality (Table 2.2).

Neutral Detergent Fiber represents the cell content of the plant material that includes carbohydrates, starch, organic acids, pectin and protein (Tainton1999). It determines the rate of digestion. Forages low in NDF are usually of high quality and have high levels of intake. Forage that is highly digestible encourages high feed intake because the faster the digestion rate, the quicker the digestive tract will be emptied and the more the space made available for more intake. Blezinger (1999) described forage with a NDF% of below 46% as very good, 47% to 60% as medium to good and above 61% as low (Table 2.2).

- Factors affecting forage quality

Growth stage, environmental condition and management practices are the primary factors that affect forage quality due to their influence on their anatomy and morphology (Collins and Fritz 2003).

Forage species and cultivars have different forage qualities. Differences in forage quality between grasses and legumes can be very large. The protein content of legumes is typically much higher than that of grasses, and legume fiber tends to digest faster than grass fibre, allowing the ruminant to eat more of the legume (Donaldson 2001).

Table 2.2 Typical ranges in hay composition showing the calculated CP %, ADF % and NDF % values along with other nutrient information

Quality Standard	CP	ADF	NDF	DDM	DMI	RFV
	---------% of DM--------			%	% of BW	
Prime*	>19	<31	<40	>65	>3.0	>151
1Very good	17-19	31-35	40-46	62-65	3.0-2.6	151-125
2 Good	14-16	36-40	47-53	58-61	2.5-2.3	124-103
3 Medium	11-13	41-42	54-60	56-57	2.2-2.0	102-87
4 Low	8-10	43-45	61-65	53-55	1.9-1.8	86-75
5 Very low	<8	>45	>65	<53	<1.8	<75

*The quality standard in the left hand column provides an overall description or rating of the samples (Blezinger 1999)

Growth stage of the forage at harvest is the fundamental factor that affects forage quality because it plays an important role in determining the fiber content of the crop that has been harvested. As the plant matures, its chemical composition is modified, hence its fundamental impact on forage (Buxton and Fales 1994). With age (maturity), digestibility and crude protein content decline drastically, whilst NDF and ADF content increases steadily (Humphreys 2005). At the booting stage, forage sorghum is highly digestible and has a higher crude protein content than the later stages.

Environmental (climate) conditions in which forage crops are grown influence the forage quality. Moisture, temperature and the amount of sunlight influence forage quality. This causes yearly, seasonal and geographical differences in forage quality. High temperatures may increase lignin accumulation and decrease quality, but drought stress may actually benefit quality by delaying maturity (Buxton 1996).

Management practices also contribute to the determination of forage quality. Chemical, morphological or physiological changes in the plant occur after an application of fertilizer because the plant respond to the amount of nutrients available by either reducing/increasing their growth or decreasing/increasing the nutrient content in their tissues (Buxton and Fales 1994). The application of nitrogen (N) fertilizer increases N concentration in the plants tissue which results in increased crude protein (Noller and Rhykerd 1974).

Harvest and storage also contribute to the quality of forage. Improper harvest techniques can seriously reduce forage quality, primarily through the loss of leaves. Storing a hay crop at an incorrect moisture content, or improper ensiling of a forage crop can dramatically lower its quality (Dickenson *et al.* 1993).

2.3.9 Utilization of forage sorghum

Animal performance is determined by the quality and quantity of fodder ingested and the proportion digested and absorbed by the animal. Quality is probably the most limiting factor in fodder production. High quality fodder can be obtained by increasing dry matter digestibility, the crude protein content and ensuring adequate levels of essential minerals. The quality of pastures can be manipulated by fertilization, the utilization stage and frequency of the pasture.

The effects of cutting frequency or stage on the dry matter yield and quality of forage sorghum follow trends similar to those of other fodder crops and grasses. As the utilization become less frequent, the plant mature, dry matter yield increases while digestibility and crude protein decreases. The variation in quality within species exists from region to region, mainly due to climatic conditions and soil differences. The utilization objective of any planted pasture should be to maximise the yield of digestible fodder without sacrificing the quality of fodder.

- Grazing

Donaldson (2001) stated that the best stage to start grazing forage sorghum is when the plants are approximately 50 cm to 70 cm high. Under normal conditions grazing may commence 5 to 6 weeks after planting and the plants must not be allowed to flower. At this stage the plant has established itself, is very palatable and has a high nutritive value. The goal of grazing should be to keep the forage in an early vegetative stage in order to maximize quality. If the forage is allowed to grow too much before grazing, quality will decline. In addition, cattle tend to waste tall forage by trampling it.

Sorghum x Sudan grass hybrids have a good potential for re-growth and are best utilised for grazing during the summer months. Grazing or cutting height of forage sorghum is critically important for regrowth and survival of plants. Plants should not be grazed down or cut too short (15 cm to 20 cm) as this will deplete the plant reserves too much and hamper the regrowth, resulting in high plant mortality. It recovers rapidly after utilization and a second cut (or grazing cycle) should be ready 30 to 35 days later. Three cuttings or grazing cycles can be produced during the season (Donaldson 2001).

Forage sorghum contains a glucoside that breaks down to release hydrocyanic acid, also known as prussic acid (Fair 1989). Prussic acid level is only high in plants that have been stressed, either by water shortages or frost. Grazing animals must be removed from the pasture when signs of wilting are observed to prevent poisoning. Dairy farmers, in particular, can feed a preventative dose of sulphur to their cows for the duration of their stay on the pasture - a tablespoonful of sulphur per cow per day will prevent prussic acid poisoning (Donaldson 2001). In spite of the danger of prussic acid poisoning from Forage sorghum, it is used on a large scale for grazing (Dickenson *et al.* 1993).

- Silage

Forage sorghum is an excellent silage crop capable of producing higher yields (about 30 t/ha to 60 t/ha) than most silage crops, depending on growing conditions. The plants may be cut during the soft dough stage of the seed. If it is cut and ensiled at a later stage, the dry matter content is too high to make good quality silage. For maximum yields they should not be utilized during the early stages of development, as this will have a detrimental effect on the yield and also result in uneven ear development (Dickenson *et al.* 1993).

The quality or the nutritive value and palatability of the silage may be improved by adding 1% to 2% molasses (in syrup or powder form) by weight during the ensiling process or it may be ensiled together with maize. A mixture of two units of maize to one unit of forage sorghum will provide excellent silage. If the material is still very wet, at an earlier stage (for example in case of damage by stalk borer or ergot) it should be allowed to wilt before ensiling (Dickenson *et al.* 1993).

Forage sorghum may also be planted for grazing as well as silage purposes in a single season. Early in the season the plants can be grazed once or twice and later be allowed to produce ears for maximum grain. The silage yield in this case will be lower, but is compensated for by the grazing (Pannar 2006).

- Hay

Pannar (2006) stated that hay production is not recommended. A major limitation to utilize forage sorghum in a hay system is the time it takes to dry in the field after cutting. This is mainly because of thick stems and broad leaves which dry relatively slowly. In the higher rainfall areas in particular, the risk of spoilt hay as a result of untimely rain is fairly high. Using a flail conditioner, it takes seven to ten days for the forage sorghum to dry sufficiently for baling. Water and fertilizers cannot be applied until the hay is removed. In effect, the delay in drying after each cut reduces the effective growing season by several days.

Where forage sorghum is planted specifically for hay production, it is recommended that the seeding rate be increased. The high plant population will result in thinner stems which will dry easier. For hay production the plants must be cut at a relatively young stage, i.e. piping stage. Later cuttings will produce higher yields, at the expense of nutritive value and a quicker drying time.

- In mixtures

Forage sorghum combines well with grazing vetch, provided it is planted in alternative rows in the early spring. Another legume to consider for combing with forage sorghum is arrow leaf clover. This mixture is advantageous because arrow leaf clover takes longer from planting to grazing than forage sorghum does. The presence of arrow leaf clover in forage sorghum will greatly improve its feed value (Fair 1989).

CHAPTER 3

MATERIALS AND METHODS

EXPERIMENTAL SITE

The study was conducted in the Gauteng Province at the Hygrotech Experimental Farm, Dewageningsdrift (DWD) and in Mpumalanga at the Nooitgedacht Agricultural Development Centre (NGT), Ermelo.

3.1 Hygrotech Experimental Farm, Dewageningsdrift (DWD)

Dewageningsdrift is situated approximately 40 km south-east of Pretoria on the Moloto road (Figure 3.1).

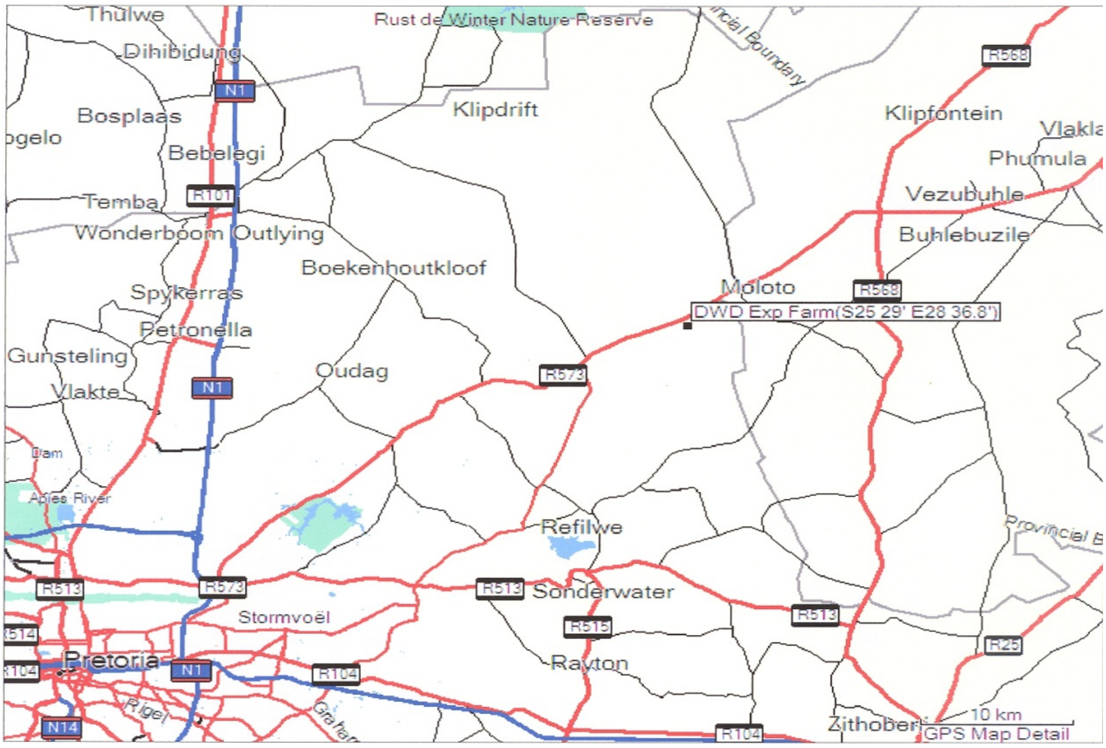

Figure 3.1: Map showing Hygrotech Experimental Farm

3.1.1 Soil

The soil was predominantly of the Clovelly form.

3.1.2 Climate

The experimental farm is characterized by hot summers and cool winters. The Long Term Average (LTA) annual rainfall on the Animal Production Institute, Roodeplaat (ARC) is 562.3 mm (Table 3.1). The mean average daily temperature varies from 11°C to 27.2°C with a minimum of 2.3°C in July and a maximum of 29.7°C in February (Table 3.1). The Roodeplaat (ARC) experimental farm is the closest climatological station (± 20 km) to Dewageningsdrift.

Table 3.1: The long term meteorological data on the Animal Production Institute, Roodeplaat (ARC)

	Frost (days)	Rain (mm)	Humidity Min (%)	Humidity Max (%)	Temp Min (ºC)	Temp Max (ºC)
Jan	0	140.5	36.9	87.8	17	29.7
Feb	0	94.7	34.3	88.0	16.6	30.2
Mar	0	61.2	34.6	88.0	15	29.1
Apr	0	28.9	31.8	89.8	11.3	27.0
May	1.3	15.9	25.3	87.3	5.8	24.1
Jun	0.8	9.2	26.2	87.5	3.9	21.7
Jul	3.9	1.9	19.8	82.1	2.3	22.2
Aug	1	4.8	19.7	79.2	5.7	24.9
Sep	0.1	6	17.4	75.7	9.2	28.2
Oct	0	59.9	23.9	79.5	13.5	29.7
Nov	0	55.9	30.4	84.8	15.3	29.6
Dec	0	83.4	32.4	87.0	16.4	30.1
Mean	-	-	27.7	84.7	11	27.2
Annual	7.1	562.3	-	-	-	-

Average first frost: 29 May
Average last frost: 25 August
Average frost season: 58 days
Average frost days/year: 7 days
Percentage years with frost: 100.00

3.1.3 Experimental design and layout

The three planting dates (large blocks) were randomly distributed over the experimental farm. Within each planting date (large blocks) a randomized block design with split-plot were used. The replications formed smaller blocks in the large blocks (planting dates). Fifty-two plots were used for each planting date: 13 cultivars x 4 replications (small blocks). The 13 cultivars in each replication and planting date were planted in randomized plots and each plot was divided into three subplots (not randomized) to apply three defoliation treatments

3.1.3.1 Treatments

The experiment on Dewageningsdrift was done in 2007 and three main treatments were applied.

- Three planting dates
- Thirteen forage sorghum cultivars
- Three defoliation treatments

Planting dates

The planting dates were:

(i) 18 December 2006 (PD 1)

(ii) 17 January 2007 (PD 2)

(iii) 14 February 2007 (PD 3)

Forage sorghum cultivars

Thirteen forage sorghum cultivars were used in the experiment (Table 3.2).

Table 3.2: The forage sorghum cultivars planted at DWD and their planting densities

Cultivars		g/7.5 m
1	Piper	10
2	Kow Kandy	10
3	Sentop	10
4	Jumbo	5
5	Everlush	5
6	Revolution	5
7	Sweet Kandy BMR	5
8	Hygrograze	5
9	Sugargraze	5
10	Kow Kandy BMR	5
11	Kow Kandy Impr. BMR	5
12	Hygrosil BMR	5
13	Silo 700	5

Defoliation treatments

Three defoliation treatments were applied in the three split plots.

- Sub-plot A , Six weekly (Dt 1): Plants were defoliated initially six weeks after planting, and after that regrowth was defoliated every six weeks.
- Sub-plot B, Grazing stage (Dt 2): Plants were defoliated repeatedly when it reached a height of ± 800 mm.
- Sub-plot C, Silage stage (Dt 3): Plants were defoliated when the seeds of the plants were at a soft dough stage.

The abbreviations in brackets (eg. Dt1) will be used for the rest of the discussion.

3.1.4 Preparation and layout of experimental plots

The land was ploughed and then worked with a disc harrow to control weeds and loosen the soil. The final preparation was done with the tiller for a fine seedbed. Forage sorghum was planted in five rows of

7.5 m per plot with the inter row spacing is 500 mm. The planting density for each cultivar is indicated on Table 3.2.

3.1.5 Fertilization

Before the experiment started no soil samples were taken. Before planting the equivalent of 150 kg/ha 2:3:4 (30) and 250 kg/ha Rapid Raiser were applied and disced in. Rapid Raiser is an organic fertilizer made of chicken manure with 30 g/kg N, 30 g/kg P and 30 g/kg K and micro elements. A nitrogen top dressing was applied in two portions, four weeks after planting and again eight weeks after planting. In each case 125 kg LAN (28%) was applied.

3.2 NOOITGEDACHT AGRICULTURAL DEVELOPMENT CENTRE (ADC)

Nooitgedacht Agricultural Development Centre is situated approximately 5 km outside of Ermelo on the N17 route between Bethal and Ermelo in the North-eastern Sandy Highveld (Acocks 1988). The site has a north-easterly aspect. Nooitgedacht is located at an altitude of 1694 m above sea level.

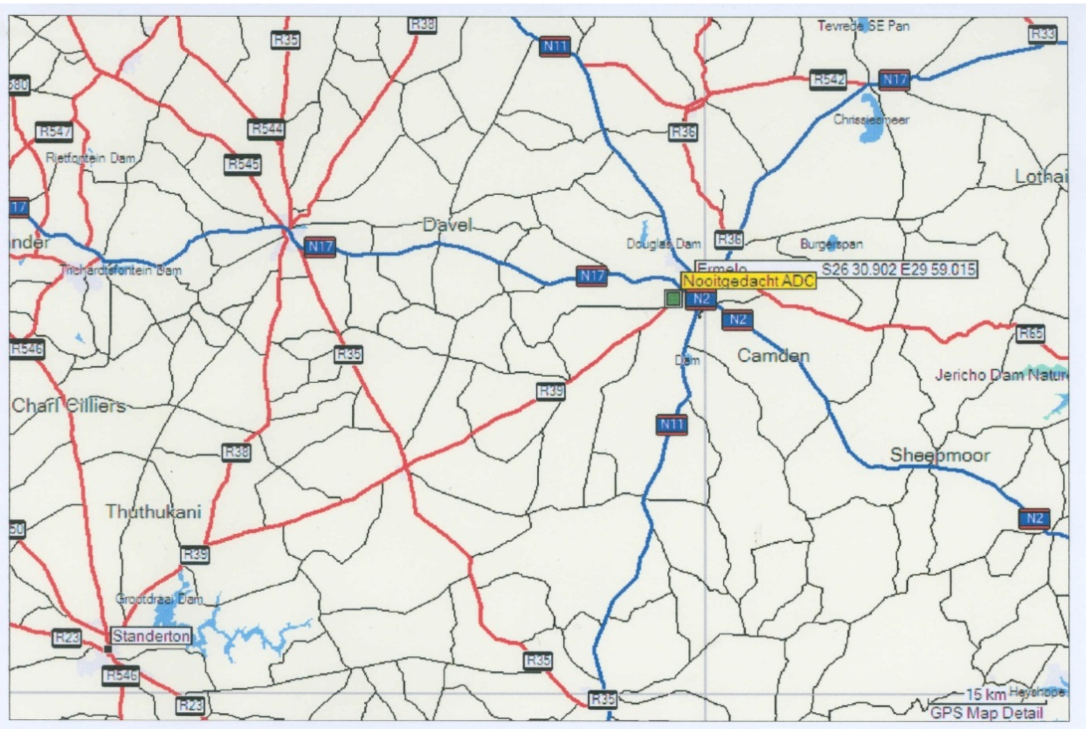

Figure 3.2: Map showing Nooitgedacht Agricultural Development Centre

3.2.1 Soil

The soils are sandy and were classified as predominantly of the Wasbank form (MacVicar *et al.* 1977) with an effective depth of 500 mm to 600 mm. The Wasbank soil form comprises an orthic A horizon over an E horizon over a hard plinthic B horizon.

3.2.2 Climate

The ADC is characterized by hot summers and cold winters. The LTA annual rainfall on the experimental farm is 703.4 mm (Table 3.3). The mean average daily temperature varies from 7.75°C to 21.7°C with a minimum of 0.2°C in June/July and a maximum of 24.7°C January (Table 3.3).

Table 3.3: The long term meteorological data at the Nooitgedacht Agricultural Development Centre

	Rain (mm)	Temp Min (ºC)	Temp Max (ºC)
Jan	126.8	13.3	24.7
Feb	72.7	12.9	24.2
Mar	68.8	11.4	23.6
Apr	35.3	8	21.5
May	10.5	3.7	19.2
Jun	7.8	0.2	16.6
Jul	6.6	0.2	17.1
Aug	12.9	3	19.5
Sep	27.1	7.1	22.9
Oct	91.4	9.5	23
Nov	114.4	11.2	23.4
Dec	129	12.5	24.3
Mean	-	7.75	21.7
Annual	703.4	-	-

KEY NOTES

Rain	mm/month	Rainfall
Tmax	ºC	Daily Maximum Temperature
Tmin	ºC	Daily Minimum Temperature

Key	Stats	Start Dt	End Dt	Yrs
Rain	Average	01/01/1970	28/02/1997	28
Tmax	Average	01/01/1970	28/02/1997	28
Tmin	Average	01/01/1970	28/02/1997	28

3.2.3 Experimental design and layout

The design and layout on Nooitgedacht were the same as for Dewageningsdrift, with the following differences: Forty eight plots were used for each planting date: 12 cultivars x 4 replications (small blocks). The 12 cultivars in each replication and planting date were planted in randomized plots and each plot was divided into three subplots (not randomized) to apply three defoliation treatments. The statistical analysis for the different planting date were done separately.

3.2.3.1 Treatments

The experiment on Nooitgedacht was done in 2007 and three main treatments were used.

- Three planting dates

- Twelve forage sorghum cultivars
- Three defoliation treatment

Planting dates

The planting dates were:

(i) 20 December 2006 (PD 1)

(ii) 22 January 2007 (PD 2)

(iii) 22 February 2007 (PD 3). These results were not collected due to poor germination and growth

Forage sorghum cultivars

Twelve forage sorghum cultivars were used in the experiment (Table 3.4)

Table 3.4: The forage sorghum cultivars planted at NGT and their planting densities

Cultivars		g/7.5 m
1	Piper	10
2	Kow Kandy	10
3	Sentop	10
4	Jumbo	5
5	Everlush	5
6	Revolution	5
7	Sweet Kandy BMR	5
8	Hygrograze	5
9	Sugargraze	5
10	Kow Kandy BMR	5
11	Kow Kandy Impr. BMR	5
12	Hygrosil BMR	5

Defoliation treatments

Three defoliation treatments were applied in the three split plots.

- Sub-plot A , Six weekly (Dt 1): Plants were defoliated initially six weeks after planting, and after that regrowth was defoliated every six weeks.
- Sub-plot B, Grazing stage (Dt 2): Plants were defoliated repeatedly when it reached a height of ± 800 mm.
- Sub-plot C, Silage stage (Dt 3): Plants were defoliated when the seeds of the plants were at a soft dough stage.

The abbreviations in brackets (eg Dt 1) will be used for the rest of the discussion.

3.2.5 Preparation and layout of experimental plots

The land was ploughed and then worked with a disc harrow to control weeds and loosen the soil. The final preparation was done with the tiller for a fine seedbed. Forage sorghum was planted in five rows of 7.5 m per plot with the inter row spacing is 500 mm. The planting density for each cultivar is indicated on Table 3.4.

3.2.6 Fertilization

Fertilization is important for optimal production. The Potassium (K) and the Phosphate (P) content in the soil was corrected according to a soil analyses. To correct the P-content 100 kg Superphosphate/ha was applied before planting commenced and n0 potassium was necessary. An initial fertilization of 50 kg LAN/ha and was applied at planting. Nitrogen (N) was applied in two applications of 30 kg N/ha each at 20 cm to 30 cm height (four weeks) and again ten weeks after planting. Nitrogen was applied on the rows at a rate of 40.1 g LAN per row.

3.3 DATA COLLECTION

All the replications were defoliated or harvested at the following stages: six weeks after planting (plus re-growth every six weeks), repeatedly at a height of 70 cm to 80 cm and at silage stage. Only the three centre rows were cut for yield determination. After determining the yield weight, the side rows were cut at the same height as the centre rows. The cutting height was 50 mm above the ground to stimulate rapid re-growth.

All the material cut from the plot was weighed to determine the green weight per plot. Samples were placed in paper bags and oven dried, at 60ºC, until it reached a constant dry weight. When the samples were dry, they were weighed to obtain the dry matter weight to calculate dry matter content.

3.3 DATA ANALYSIS

Data was analyzed using the statistical program GenStat® (Payne *et al.* 2009). Results were compared against each other by using an Anova and the Fischer's protected LSD within one planting date, but separately for the two locations (DWD and NGT). It was done separately for location and planting date.

CHAPTER 4

RESULTS

4.1 RESULTS AT DEWAGENINGDSDRIFT (DWD)

4.1.1 Meteorological data

The meteorological data during the 2006/2007 season in the DWD area are shown in Table 4.1. The Roodeplaat meteorological station is situated approximately 20 km west of DWD.

Table 4.1: Meteorological data for the 2006/2007 season at the Animal Research Institute, Roodeplaat (ARC)
(Source: ISCW, Agromet section, P/ Bag 79, Pretoria, 0001)

2006	Period	Rain	FD	RHx	RHn	ETo	Rs	Tmax	Tmin	U2
July	1 - 31	0.0	0.0	82.2	19.1	2.6	15.0	23.7	3.6	0.9
August	1 - 31	16.8	3.0	82.4	22.9	3.6	18.2	22.6	4.8	1.6
September	1 - 30	0.9	0.0	76.6	15.2	4.9	22.8	27.6	7.8	1.3
October	1 - 31	17.0	0.0	77.7	18.6	6.0	23.6	31.1	13.9	1.5
November	1 - 30	103.8	0.0	85.9	33.2	5.3	22.1	28.9	14.8	1.3
December	1 - 31	79.6	0.0	82.7	27.9	6.5	24.5	31.9	17.6	1.6
Total		218.1								
2007										
January	1 - 31	60.7	0.0	85.9	25.0	6.1	27.0	31.7	15.9	1.1
February	1 - 28	27.9	0.0	81.0	18.3	6.5	27.3	33.8	15.8	1.3
March	1 - 31	7.2	0.0	78.3	21.0	5.5	23.1	32.1	14.8	1.2
April	1 - 30	12.5	0.0	85.8	23.1	4.0	18.8	28.5	11.5	1.1
May	1 - 31	0.3	4.0	76.5	14.7	3.2	18.4	24.9	4.4	1.0
June	1 - 30	30.1	2.0	85.5	23.6	2.5	16.1	21.4	3.3	1.0
Total		138.7								

KEY NOTES :

Rain	mm/mnth	Rainfall
FD	days	Frost Days
RHx	%	Maximum Daily Relative Humidity
RHn	%	Minimum Daily Relative Humidity
ETo	mm/day	Penman-Monthieth (FAO-56)
Rs	MJ/m²/day	Radiation
Tmax	ºC	Daily Maximum Temperature
Tmin	ºC	Daily Minimum Temperature
U2	M/s	Wind Speed

According to the meteorological data in Table 4.1 the total rainfall for July to December 2006 was 218.1 mm, which compared well with the long term meteorological data of 211.9 mm during the same period. The good rainfall of November (103.8 mm) and December (79.6 mm) assured fast germination and early production. The total amount of rainfall recorded from January to June 2006 was 138.7 mm, which is much lower than the long term meteorological data of 350.4 mm for the same months. The low rainfall between January and June could have influenced the total dry matter production of the season, which will be discussed later.

The maximum temperatures recorded during the study in July, October and December 2006 were higher, while those recorded for August, September and November were lower than the long term meteorological data of the same months. The minimum temperatures recorded for July and October were higher, while temperatures for the other months were lower than the long term climatic data for the same months. The maximum temperatures between January and June 2007 were higher than that of the long term meteorological data for the same months, while the minimum temperatures recorded during the study were lower.

4.1.2 Results of the December planting date

As indicated in Paragraph 3.1.4 (Chapter 3), the 13 forage sorghum cultivars were subjected to three defoliation treatments: (i) defoliated six weekly (Dt 1), (ii) cut repeatedly when it reached a grazing stage (Dt 2) that was taken as (± 800 mm high) and (iii) at a silage stage (Dt 3). The total DM production obtained during the three treatments was statistically analyzed together. Results from the six weekly (Dt 1) defoliation treatment and the silage stage (Dt 3) were also analyzed separately to evaluate differences between different cuts. Plants (cultivars) in the grazing stage (Dt 2) treatment reached the prescribed height on different days and for that reason results on separate days were not analyzed.

For the rest of the discussion the abbreviation as shown in the abbreviation list (page xi) will be used.

<u>4.1.2.4 Total Dry Matter (TDM) production for December planting date on Dewageningsdrift</u>

The total dry matter production of the cultivars at the different defoliation treatments are shown in Table 4.2 and Figure 4.1. According to the statistical analyses in Addendum A1, significant differences ($P \leq 0.001$) were observed for cultivars and cutting treatment as the main treatments and the interaction between cutting treatment and cultivars. The significant differences, per cultivars, between different cuts are shown with the symbols <, = and >.

When comparing the TDM production of different cultivars (per cutting treatment) with the Fischer's protected LSD of 4372, significant differences occurred, as shown by different Roman letters in Table 4.2. The TDM productions were grouped (according to significance) in different production groups, as shown in different colours in Table 4.2:

- Six weeks: Yellow = 5000 kg/ha to 9999 kg/ha; Brown = 10000 kg/ha to 14999 kg/ha; Red = > 15000 kg/ha.
- Grazing stage: Yellow = <5000 kg/ha; Orange = 5000 kg/ha to 9999 kg/ha; Light brown = 10000 kg/ha to 14999 kg/ha; Red = > 15000 kg/ha.
- Silage stage: Yellow = < 15000 kg/ha; Orange = 15000 kg/ha to 19999 kg/ha; Light brown = 20000 kg/ha to 24999 kg/ha; Red = > 25000 kg/ha.

Table 4.2: Total DM production (kg/ha) of forage sorghum cultivars planted in December on DWD, at the different cutting treatments

Forage sorghum Cultivars	Six weeks	Grazing	Silage
Everlush	11247 bcde >	4886 fg <	18006 bcde
Revolusion	11809 bcd =	11016 bc <	19501 bcd
Kow Kandy BMR	13504 b =	11494 ab =	15140 efg
Hygrosil BMR	7903 def =	5140 efg <	17098 cdef
Hygrograze	7150 ef =	7009 cdefg <	15466 defg
Sentop	14140 b =	9148 bcdef =	13481 g
Kow Kandy Impr. BMR	12624 bc >	6539 defg <	21189 bc
Piper	12765 b =	10455 bcd =	11647 fg
Jumbo	19496 a =	15537 a <	26883 a
Sweet Kandy BMR	5213 f =	9369 bcde <	14315 efg
Kow Kandy	10199 bcde =	12478 ab <	21070 bc
Sugargraze	8273 cdef =	6596 defg <	21957 b
Silo 700	5557 f =	4363 g <	17242 cdef
Mean	10760 b	8541 c	17923 a

LSD (P≤ 0.001) Cv X Cut: 4372
Cut: 1136
Coefficient of variation = 16.2%
< > shows significant difference between cuts (LSD = 4372)
= shows no significant difference
Values with the same Roman letter do not differ significantly

At the six weekly defoliation treatment (Dt 1), the TDM production of the cultivars ranged between 5213 kg/ha and 19496 kg/ha with Jumbo being the highest producer and Sweet Kandy BMR as the lowest producer.

Three production groups were identified in the six weeks (Dt 1) treatment:

- High producers: > 15000 kg/ha, red: Jumbo (19496 kg/ha).
- Medium producers: 10000 kg/ha to 14999 kg/ha, light brown: Sentop, Kow Kandy BMR, Piper, Kow Kandy Impr. BMR, Revolusion, Everlush and Kow Kandy, with the DM production ranging between 10199 kg/ha and 14140 kg/ha.
- Low producers: < 10000 kg/ha, yellow: Sugargraze, Hygrosil BMR, Hygrograze BMR, Silo 700 and Sweet Kandy BMR with the DM production ranging between 5213 kg/ha and 8273 kg/ha.

At the grazing stage TDM production of cultivars ranged between 4363 kg/ha and 15537 kg/ha with Jumbo being the highest producer and Silo 700 as the lowest producer.
Four production groups were identified at a grazing stage (Dt 2) treatment:

- High producers: > 15000 kg/ha, red: Jumbo (15537 kg/ha).
- Medium high producers: 10000 kg/ha to 14999 kg/ha, light brown: Kow Kandy, Kow Kandy BMR, Revolusion and Piper with the DM production ranging between 10455 kg/ha and 12478 kg/ha.
- Medium low producers: 5000 kg/ha to 9999 kg/ha, orange: Sweet Kandy BMR, Sentop, Hygrograze BMR, Sugargraze, Kow Kandy Impr. BMR and Hygrosil BMR with the DM production ranging between 4886 kg/ha and 9369 kg/ha.
- Low producers: < 5000 kg/ha, yellow: Silo 700 (4363 kg/ha) and Everlush.

At the silage stage, the TDM production of cultivars ranged between 11647 kg/ha and 26883 kg/ha, with Jumbo producing higher than all the cultivars and Piper being the lowest producer.
Four production groups were identified at a silage stage (Dt 3) treatment.

- High producers: > 25000 kg/ha, red: Jumbo (26883 kg/ha).
- Medium high producers: 20000 kg/ha to 24999 kg/ha, light brown: Sugargraze, Kow Kandy Impr. BMR and Kow Kandy with the DM production of 21957 kg/ha, 21189 kg/ha and 21070 kg/ha, respectively.
- Medium low producers: 15000 kg/ha to19999 kg/ha, orange: Revolusion, Everlush, Silo 700, Hygrosil BMR, Hygrograze BMR, Kow Kandy BMR and with the DM production ranging between 14315 kg/ha and 19501 kg/ha.

- Low producers: < 15000 kg/ha, yellow: Sweet Kandy BMR, Sentop and Piper with the DM production of 14315 kg/ha 13481kg/ha and 11647 kg/ha respectively.

The influence of cutting treatments (as the main effect) on the TDM production is shown in Table 4.2 and Figure 4.1. The three defoliation treatment differed significantly (P≤ 0.001, LSD = 1136) from each other with 17923 kg/ha at a silage stage, 8541 kg/ha at a grazing stage and 10760 kg/ha at a six week stage. The TDM at silage stage (Dt 3) was significantly the highest followed by the six weekly (Dt 1) and the TDM at grazing stage (Dt 2) was significantly the lowest.

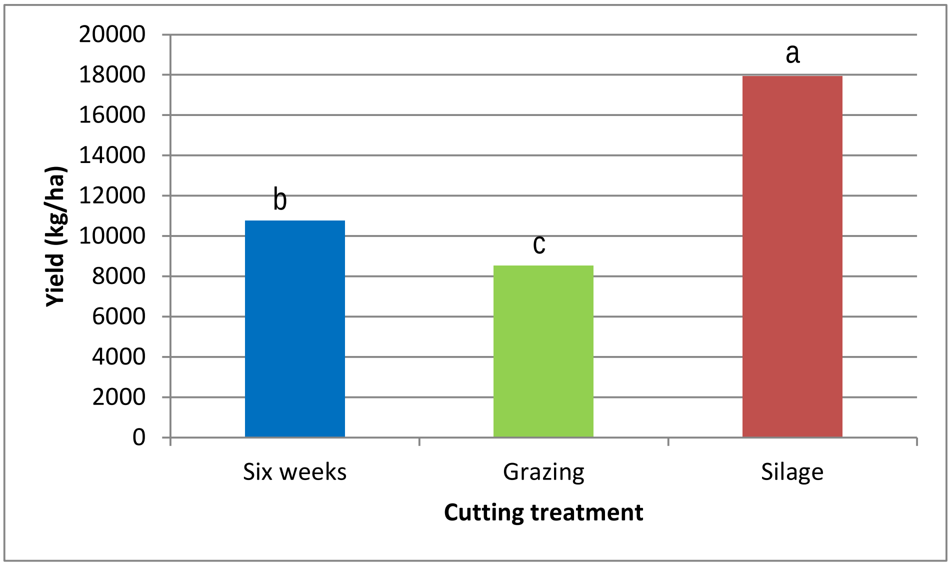

Figure 4.1: The TDM production (kg/ha) of the forage sorghum cultivars planted in December, at DWD, as influenced by defoliation treatments

4.1.2.2 DM production of forage sorghum cultivars planted at DWD in December and defoliated every six weeks (Dt 1)

On the experimental plots that were planted in December and defoliated six weekly (Dt 1), four cuts were achieved for the season. According to the statistical analyses in Addendum A2, significant differences (P≤ 0.001) in dry matter (DM) production were observed for cultivars and cuts (as main treatment), as well as for the interaction between cuts and cultivars. The results are shown in Table 4.3, Figure 4.2.1 to 4.2.3 and Figure 4.3.The results were compared with a Fisher's protected LSD of 1642.9 for the interaction and 455.7 for cutting date.

The production trends, as influenced by cultivars, were classified in production groups (per separate cuts) that are shown in different colours in the table: Red = high production group, light brown = medium high production group, orange = medium low production group and yellow = low production group. The colour codes are used to compare cultivars per cutting. The significant difference of the cultivars between cuts are shown with the symbols <, = and >. Take notice of the difference between cuts and cutting treatments. Cutting treatments (Dt 1, Dt 2 and Dt 3) were explained on page 28, while cuts represent the separate regrowth cuts per cutting treatment.

Table 4.3: DM production (kg/ha) of forage sorghum cultivars planted in December, at DWD, and defoliated every six weeks

Forage sorghum Cultivars	Cut 1 18 Jan	Cut 2 09 Mar	Cut 3 28 Apr	Cut 4 17 Jun
Everlush	3044 ab =	3379 cde =	4656 bcd	168 a
Revolusion	1953 bc <	4661 bcd =	5138 bc	57 a
Kow Kandy BMR	3001 ab =	4582 bcd =	5820 ab	99 a
Hygrosil BMR	2626 bc =	3050 de =	2127 fg	99 a
Hygrograze	2149 bc =	2536 e =	2422 f	42 a
Sentop	4878 a =	4344 cd =	4832 bcd	85 a
Kow Kandy Impr. BMR	3054 ab <	6217 ab >	3224 def	128 a
Piper	3280 ab =	4702 bc =	4571 bcd	214 a
Jumbo	4412 a <	7862 a =	6938 a	285 a
Sweet Kandy BMR	1840 bc =	2172 e =	1131 g	71 a
Kow Kandy	2334 bc <	4295 cde =	3200 def	370 a
Sugargraze	2074 bc =	1966 e <	4118 cde	114 a
Silo 700	1176 c =	1840 e =	2499 ef	42 a
Mean	2756b	3970a	3898a	137c

LSD (P≤ 0.001): Interaction Cv X Cut = 1642.9
Cuts = 455.7
Coefficient of variation = 30.9%
< > shows significant difference between cuts (LSD = 1642.9)
= shows no significant difference
Values with the same Roman letter do not differ significantly

The DM production of cultivars in Cut 1 ranged from 1176 kg/ha for Silo 700 to 4878 kg/ha for Sentop and was, on average 2756 kg/ha. In Cut 2 the DM production of cultivars ranged from 1840 kg/ha for Silo 700 to 7862 kg/ha for Jumbo and was, on average, 3970 kg/ha. In Cut 3 the DM production of cultivars ranged from 1131 kg/ha for Sweet Kandy BMR to 6938 kg/ha for Jumbo and was, on average, 3898 kg/ha. In Cut 4 the DM production ranged from 42 kg/ha for Silo 700 and Hygrograze to 370 kg/ha for Kow Kandy and was, on average, 137 kg/ha. Sentop, Jumbo, Kow Kandy Impr. BMR and Kow Kandy BMR were the highest producers (red in table), whereas Silo 700 produced the lowest in most of the cuts.

To present a visual impression of the seasonal DM production, the production trends were shown in Figure 4.2.1 to 4.2.3. The thirteen forage sorghum cultivars were divided in three seasonal production groups:

- Group 1 was the cultivars that started slow early in the season and reached their production peaks during late August (Figure 4.2.1).
- Group 2 were those that started relatively slow in the season with a production peak during early March and with a gradual decrease towards June (Figure 4.2.2).
- Group 3 were the cultivars that started relatively fast in January (2000 kg/ha to 5000 kg/ha) and peaked during early March, with a decrease towards June (Figure 4.2.3).

According to Figure 4.2.1, two different production groups could be identified on the basis of their seasonal production trends:

- Cultivars that produced relatively high (± 3000 kg/ha) in January. They reached their maximum production peaks at the end of April. This group included Kow Kandy BMR that peaked with ± 6000 kg/ha, Piper with 5000 kg/ha and Everlush with ± 4600 kg/ha.
- Cultivars that started with lower than 2000 kg/ha, reaching a maximum production in late April. This group included Silo 700 with ± 2500 kg/ha and Sugargraze with ± 4100 kg/ha.

The cultivars in the two groups can be classified as late season producers.

Figure 4.2.2 indicates cultivars with relatively low productions in January, but relatively high production peaks in early March:

- Kow Kandy: 2334 kg/ha in January and 4300 kg/ha in early March.
- Kow Kandy Improved BMR: ± 3054 kg/ha in January and 5200 kg/ha in early March.
- Jumbo: ± 4200 kg/ha in January and 8100 kg/ha in early March.

These cultivars can be classified as mid-growing season producers.

Figure 4.2.3 indicates three cultivars that started with 2000 kg/ha to 2700 kg/ha in January, but did not increase significantly after that.

- Sweet Kandy BMR with ± 2000 kg/ha in early March.
- Hygrograze with ± 2800 kg/ha in early March.
- Hygrosil BMR with ± 3000 kg/ha in early March.
- Sentop started with ± 4900 kg/ha and peaked in early March with ± 5200 kg/ha.

These four cultivars can be classified as early season growers

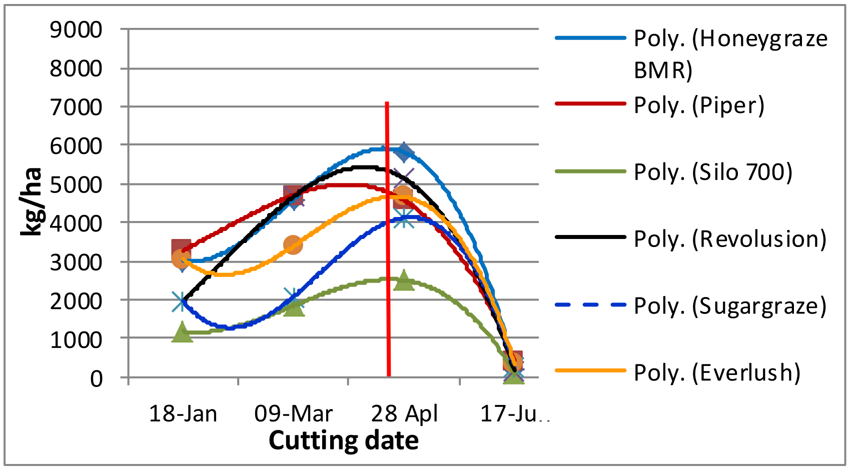

Figure 4.2.1: Seasonal growth trend of late producing forage sorghums, planted in December and defoliated every six weeks, at DWD

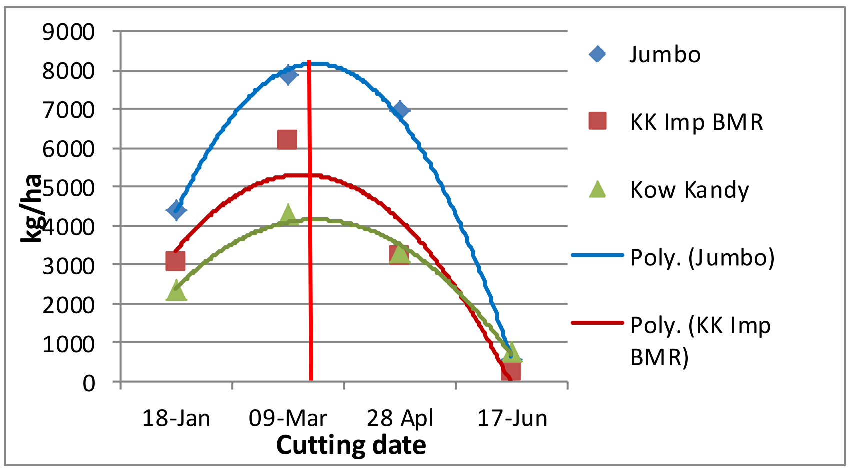

Figure 4.2.2: Seasonal growth trend of mid-season producing forage sorghums, planted in December and defoliated every six weeks, at DWD

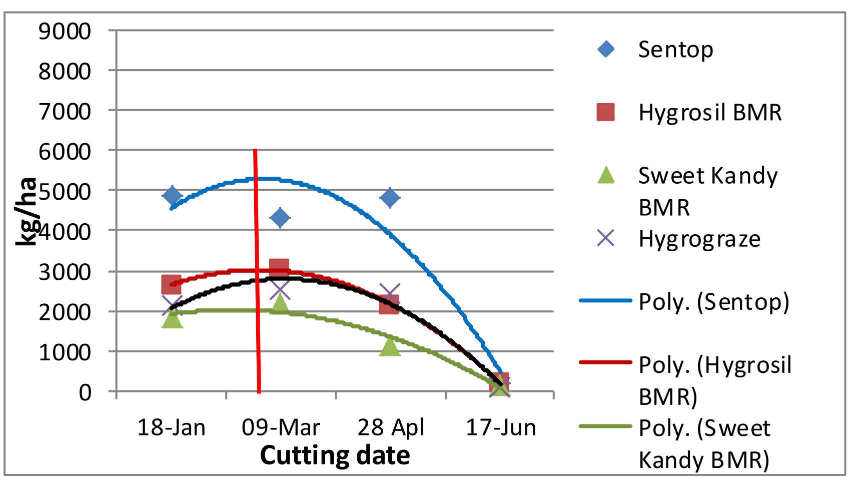

Figure 4.2.3: Seasonal growth trend of early producing forage sorghums, planted in December and defoliated every six weeks, at DWD

The average production on the four cutting dates for the six weekly defoliation treatment is shown in Figure 4.3. When comparing these DM productions with the Fishers protected LSD of 455.7 (Table 4.2), the average production of Cut 1 was 2756 kg/ha, for Cut 2 it was 3970 kg/ha, for Cut 3 it was 3898 kg/ha and for Cut 4 it was 137 kg/ha. The early March cut (Cut 2) and the end of April cut (Cut 3) were significantly higher than the mid-January cut (Cut 1) and the mid-June cut (Cut 4). The last two mentioned cuts (Cut 2 and Cut 3) did not differ significantly from each other. The DM production in Cut 1 and Cut 4 differed significantly, but were also significantly lower than those measured in March (Cut 2) and April (Cut 3).

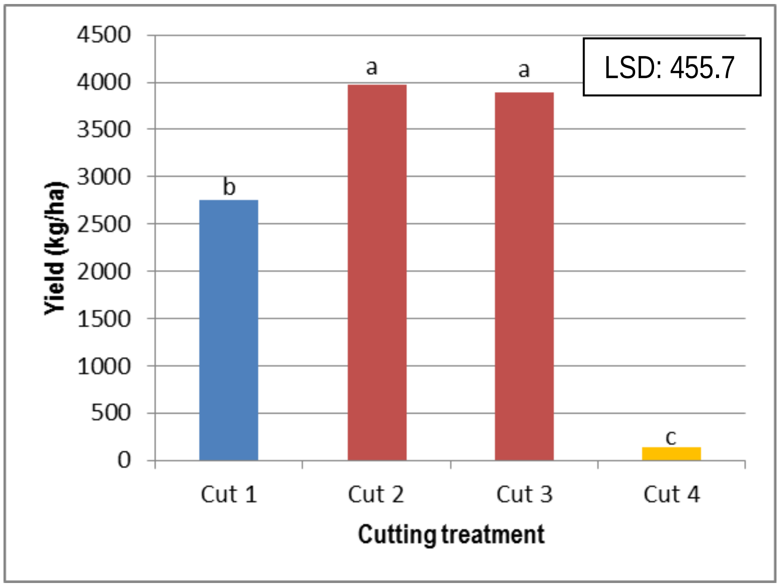

Figure 4.3: The average six-weekly DM production regrowth (kg/ha) of forage sorghum cultivars planted in December at DWD
Roman letters (a, b, c) indicate significant difference

<u>4.1.2.3 Dry matter production when defoliated at the grazing stage (Dt 2)</u>

The ideal grazing height for forage sorghum was taken as ± 800 mm and the plants were defoliated at that height to evaluated DM production. Dannhauser (1991) suggested a grazing height of 600 mm to 1000 mm. The cultivars reached an average height of ± 800 mm at different dates and as a result of that different cultivars in different plots were not cut on the same day. For that reason, only total production (all cuts together) was analyzed statistically and shown in Table 4.2. A repetition of these results is shown in Table 4.4 and Figure 4.4 without statistical analyzes.

At the grazing stage, DM production of cultivars ranged between 4363 kg/ha and 15537 kg/ha, with Jumbo being the highest producer and Silo 700 the lowest producer. Subjectively, the DM production of the cultivars could be classified in four production groups (Table 4.3): Red = > 15000 kg/ha (high producers), light brown = 10000 kg/ha to 14999 kg/ha (medium high producers), orange = 6000 kg/ha to 9999 kg/ha (medium low producers), yellow = < 6000 kg/ha (low producers):

- The highest producer was Jumbo with a production of 15537 kg/ha.
- The medium high producers were Kow Kandy, Kow Kandy BMR, Revolusion and Piper with the production ranging between 10455 kg/ha and 12478 kg/ha.
- The medium low producers were Sentop, Hygrograze, Sugargraze, Kow Kandy Impr. BMR and Sweet Kandy BMR with the production ranging between 6369 kg/ha and 9148 kg/ha.
- The low producers were Hygrosil BMR, Everlush and Silo 700 which produced between 5140 kg/ha and 4364 kg/ha.

Table 4.4: The DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated at a grazing stage, at DWD

Forage sorghum Cultivars	Total (kg/ha)
Jumbo	15537
Kow Kandy	12478
Kow Kandy BMR	11494
Revolusion	11016
Piper	10455
Sentop	9148
Hygrograze	7009
Sugargraze	6595
Kow Kandy Impr. BMR	6539
Sweet Kandy BMR	6369
Hygrosil BMR	5140
Everlush	4886
Silo 700	4363
Mean	8541

The results in Table 4.4 are also shown more visually in Figure 4.4.

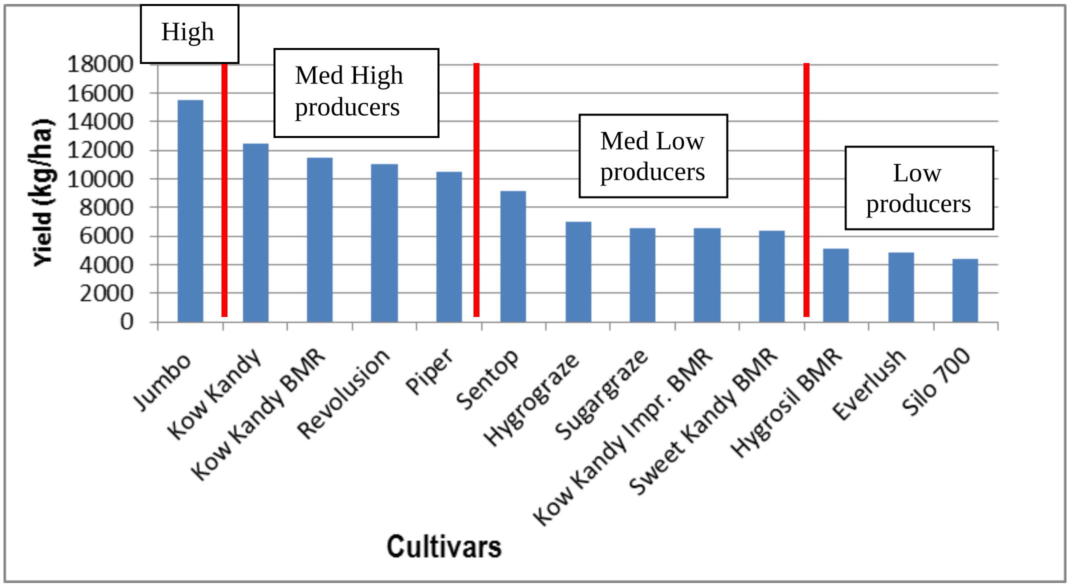

Figure 4.4: DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated at a grazing stage at DWD

4.1.2.4: Dry matter production at the silage stage (Dt 3)

The experimental plots that were planted in December were harvested at a silage stage on the 04th April. After that, re-growth occurred that was cut on the 04th June because the plants started to change to a dormant stage. According to the statistical analyses in Addendum A3, significant differences ($P \leq 0.001$) were observed for cuts whereas cultivars and interaction between cuts and cultivars were also significant ($P \leq 0.05$). The results are shown in Table 4.5 and Figure 4.5. Results were classified in production groups (per separate cuts) by using the Fischer's protected LSD of 422.4. They are shown in different colours in the table: Red > 25000 kg/ha, light brown = 17500 kg/ha to 24999 kg/ha, orange = 13000 kg/ha to 17499 kg/ha and yellow < 13000 kg/ha. The colour codes are used to compare cultivars per cutting. Significant differences of the cultivars within cuts are shown with the symbols <, = and >.

The DM production at the silage stage in Cut 1 ranged from 9329 kg/ha for Piper to 25975 kg/ha for Jumbo. When comparing the DM production of the cultivars with the Fishers protected LSD of 4224, the DM production could be classified in four production groups:

- High producers (red): Jumbo with 25975 kg/ha
- Medium-high producers (light brown): Sugargraze, Kow Kandy Impr. BMR, Kow Kandy, Revolusion, Everlush.

- Medium-low producers (orange): Silo 700, Hygrosil BMR, Hygrograze, Kow Kandy BMR, Sweet Kandy BMR and Sentop.
- Low producers (yellow): Piper with 9329 kg/ha.

Table 4.5: The DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated at a silage stage at DWD

Fodder sorghum Cultivars	Cut 1 04 April	Cut 2 04 June
Jumbo	25975 a >	909 a
Sugargraze	21330 b >	627 a
Revolusion	17998 bcde >	1504 a
Kow Kandy	18313 bcd >	2757 a
Sentop	13168 gh >	313 a
Everlush	17536 bcdef >	470 a
Kow Kandy BMR	13824 efg >	1316 a
Piper	9329 h >	2319 a
Hygrograze	15059 defg >	407 a
Kow Kandy Impr. BMR	19780 bc >	1410 a
Sweet Kandy BMR	13531 fgh >	783 a
Silo 700	16553 cdefg >	689 a
Hygrosil BMR	16346 cdefg >	752 a
Mean	16826 [a]	1097 [b]
LSD (P≤ 0.001) Interaction; Cv X Cut: 4224 Cut: 1171 Coefficient of variation = 21.8% < > shows significant difference between cuts (LSD = 4224) = shows no significant difference Values with the same Roman letter do not differ significantly		

DM production on 04 June (re-growth) ranged from 313 kg/ha to 2757 kg/ha, with Kow Kandy as the highest producer and Sentop as the lowest producer. The DM production in Cut 1 (silage stage) was significantly higher than that of the re-growth (04 June) (16826 kg/ha vs 1097kg/ha Table 4.5).

The results in Table 4.4 are also shown visually in Figure 4.4.

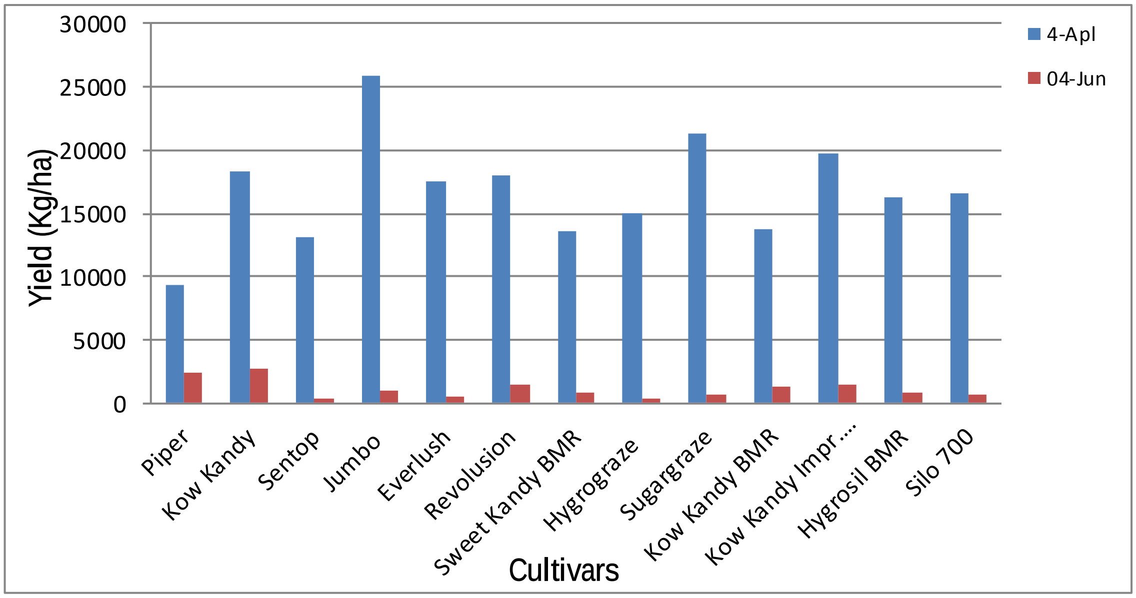

Figure 4.5: DM production (kg/ha) of forage sorghum cultivars planted in December at DWD and defoliated at a silage stage

4.1.2.5 Summary of forage sorghum results when planted in December

- Six weekly cut (Dt 1) DM production

The following conclusions can be made when comparing the DM production of cultivars planted in December at DWD and defoliated six weekly (Table 4.3):

Six weeks after planting (18 January), the average DM production of cultivars was 2756 kg/ha. The highest producers were Sentop (4878 kg/ha) and Jumbo (4412 kg/ha) while the lowest producer was Silo 700 (1176 kg/ha). The first six weeks regrowth (Cut 2, 09 March) was, on average, higher (3970 kg/ha) than the three other cuts. The highest DM productions were measured with Jumbo (7862 kg/ha) and Kow Kandy Impr. BMR (6217 kg/ha) and the second highest group included Piper, Revolusion, Kow Kandy BMR, Sentop and Kow Kandy, followed by the rest that were below 3683 kg/ha. The lowest producer was Silo 700.

A further six weeks of regrowth (Cut 3, 28 April) produced, on average, 4223 kg/ha, with Jumbo, Kow Kandy BMR and Revolusion producing the highest (> 6000 kg/ha). On average, the lowest DM production of 137 kg/ha was measured on the 17th June (Cut 4). The production of cultivars was between 42 kg/ha and 285 kg/ha.

Comparing DM productions across the cutting dates: Sentop and Jumbo could be described as early to mid-season producers and Kow Kandy Improved BMR, Piper, Revolusion and Kow Kandy BMR as mid to late season producers.

In terms of total production the following cultivars were the highest producers: Jumbo (19496 kg/ha), Sentop (14140 kg/ha), Kow Kandy BMR (13504 kg/ha), Piper (12765 kg/ha), Kow Kandy Improved BMR (12624 kg/ha) and Revolusion (11809 kg/ha). The two lowest producers were Silo 700 (5557 kg/ha) and Sweet Kandy BMR (5213 kg/ha).

- Defoliation at grazing stage (± 800mm)

According to the results in Table 4.4 the following production norms should be mentioned:
The DM production of cultivars, when defoliated at the grazing stage, ranged between 4363 kg/ha and 15537 kg/ha with Jumbo being the highest producer and Silo 700 the lowest producer. The highest producers (top five in ranking) were: Jumbo, Kow Kandy, Kow Kandy BMR, Revolusion and Piper, with DM production ranging between 10455 kg/ha and 12478 kg/ha. The three lowest producers were Hygrosil BMR, Everlush and Silo 700, which produced between 5140 kg/ha and 4364 kg/ha.

- Silage stage (Dt 3)

The DM production of the cultivars defoliated at a silage stage (Dt 3); ranged from 9329 kg/ha for Piper as the lowest producer to 25975 kg/ha for Jumbo. The high producers (top five in ranking) were Jumbo (25975 kg/ha), Sugargraze (21330 kg/ha), Kow Kandy Improved BMR (19780 kg/ha), Kow Kandy (18313 kg/ha) and Revolusion (17998 kg/ha). The rest of the cultivars produced between 13168 kg/ha and 17536 kg/ha.

The re-growth (bonus production) on the 04 June yielded an average production of 1097 kg/ha, DM production of cultivars ranged between 313 kg/ha and 2319 kg/ha.

4.1.3 Results of the January planting date on Dewageningsdrift

As indicated in Paragraph 3.1.4 (Chapter 3), the 13 forage sorghum cultivars were subjected to three defoliation treatments: (i) six weekly (Dt 1), (ii) cut repeatedly when it reached a grazing stage (Dt 2) that was taken as (± 800 mm high) and (iii) at a silage stage (Dt 3). The total DM production obtained during the three treatments was statistically analyzed together. Results from the six weekly (Dt 1) defoliation treatment and the silage stage (Dt 3) were also analyzed separately to evaluate differences between different cuts. Plants (cultivars) in the grazing stage (Dt 2) treatment reached the prescribed height on different days and for that reason results on separate days were not analyzed.

4.1.3.1 Total Dry Matter (TDM) production for January planting date at Dewageningsdrift

According to the statistical analyses in Addendum A4, a significant difference in TDM production was observed for cutting treatment ($P \leq 0.001$) and for cultivars ($P \leq 0.05$) as the main treatment. The interaction between cutting treatment and cultivars was non-significant ($P \leq 0.972$) and the results are shown in Table 4.6, Figure 4.6 and Figure 4.7.

When comparing the results, as influenced by the interaction between cultivars and cutting treatment with a Fisher's protected LSD of 7377 within each cutting treatment, a trend of significant differences occurred. The differences in TDM production are indicated with different colours in Table 4.9. The colour codes differed between the three cutting treatments (Dt 1, Dt 2 and Dt 3).

At the six weekly defoliation treatment (Dt 1), the TDM production of the cultivars ranged between 2354 kg/ha and 7679 kg/ha, with Jumbo being the highest and Hygrosil BMR the lowest producer. Four production groups were identified subjectively at the six weeks (Dt 1) defoliation treatment:

- High producers: > 7000 kg/ha, red: Jumbo, Sugargraze and Revolusion with the DM production of 7679 kg/ha, 7636 kg/ha and 7442 kg/ha, respectively.
- Medium high producers: 5000 kg/ha to 6999 kg/ha, light brown: Kow Kandy, Sentop, Everlush and Kow Kandy BMR with DM productions ranging between 5444 kg/ha and 6725 kg/ha.
- Medium low producers: 3000 kg/ha to 4999 kg/ha, orange: Piper, Hygrograze, Kow Kandy Impr. BMR and Sweet Kandy BMR with DM productions ranging between 3013 kg/ha and 4921 kg/ha.
- Low producers: < 3000 kg/ha, yellow: Silo 700 and Hygrosil BMR with DM productions of 2519 kg/ha and 2354 kg/ha, respectively.

Table 4.6: Total DM production (kg/ha) of forage sorghum cultivars planted in January

Forage sorghum Cultivars	Six weeks	Grazing	Silage
Everlush	5549 a =	3767 a <	13059 b
Revolusion	7442 a =	5400 a <	15835 ab
Kow Kandy BMR	5444 a =	3329 a <	13499 b
Hygrosil BMR	2354 a =	2903 a <	12613 b
Hygrograze	4866 a =	5136 a <	16570 ab
Sentop	5594 a =	4830 a <	17312 ab
Kow Kandy Impr. BMR	3330 a =	4544 a <	12236 b
Piper	4921 a =	3698 a <	14200 b
Jumbo	7679 a =	4973 a <	22100 a
Sweet Kandy BMR	3013 a =	5592 a =	12275 b
Kow Kandy	6725 a =	4661 a <	16155 ab
Sugargraze	7636 a =	4881 a <	18350 ab
Silo 700	2519 a =	6425 a =	10991 b
Mean	5159 ^{b}	4950 ^{b}	15015 ^{a}
LSD ($P \leq 0.001$) Cv X Cut: 7377 Cut: 2046 Coefficient of variation = 53.7% < > shows significant difference between cuts (LSD = 7377) = shows no significant difference Values with the same Roman letter do not differ significantly			

At the grazing stage, the TDM production of cultivars ranged between 2903 kg/ha and 6425 kg/ha with Silo 700 the highest and Hygrosil BMR the lowest producer.

Four production groups were identified subjectively at the grazing stage (Dt 2) defoliation treatment:

- High producers: > 6000 kg/ha, red: Hygrosil BMR (6425 kg/ha).
- Medium high producers: 5000 kg/ha to 5999 kg/ha, light brown: Sweet Kandy BMR, Revolusion and Hygrograze with DM productions of 5592 kg/ha, 5400 kg/ha and 5136 kg/ha, respectively.
- Medium low producers: 3000 kg/ha to 4999 kg/ha, orange: Jumbo, Sugargraze, Sentop, Kow Kandy, Kow Kandy Impr. BMR, Everlush, Piper and Kow Kandy BMR with DM productions ranging between 3329 kg/ha and 4973 kg/ha.
- Low producers: < 3000 kg/ha, yellow: Silo 700 (2903 kg/ha).

At a silage stage, the TDM production of cultivars ranged between 10991 kg/ha and 22100 kg/ha with Jumbo producing higher than all the cultivars and Silo 700 the lowest producer.

Three production groups were identified subjectively at the silage stage defoliation (Dt 3) treatment:

- High producers: > 22000 kg/ha, red: Jumbo (22100 kg/ha).
- Medium producers: 15000 kg/ha to 20000 kg/ha, light brown: Sugargraze, Sentop, Hygrograze, Kow Kandy and Revolusion with DM productions ranging between 15835 kg/ha and 18350 kg/ha.
- Low producers: 10000 kg/ha to 14999 kg/ha, orange: Piper, Kow Kandy BMR, Everlush, Hygrosil BMR, Sweet Kandy BMR, Kow Kandy Impr. BMR and Silo 700 with DM productions ranging between 10991 kg/ha and 14200 kg/ha.

Although the influence of the interaction between defoliation treatment and cultivar had no significant ($P \leq 0.972$) influence on the TDM production, the following trend was observed when comparing results with a Fishers protected LSD of 4372:

- The TDM production at the silage treatment was in eleven cultivars significantly higher as in the other two defoliation treatments. In the case of Sweet Kandy BMR (12275 kg/ha) and Silo 700 (10991 kg/ha) the TDM production was higher but not significantly.
- The average TDM production at the six week defoliation treatment tends to be higher as in the case of the grazing stage defoliation, but not significantly (Figure 4.6).

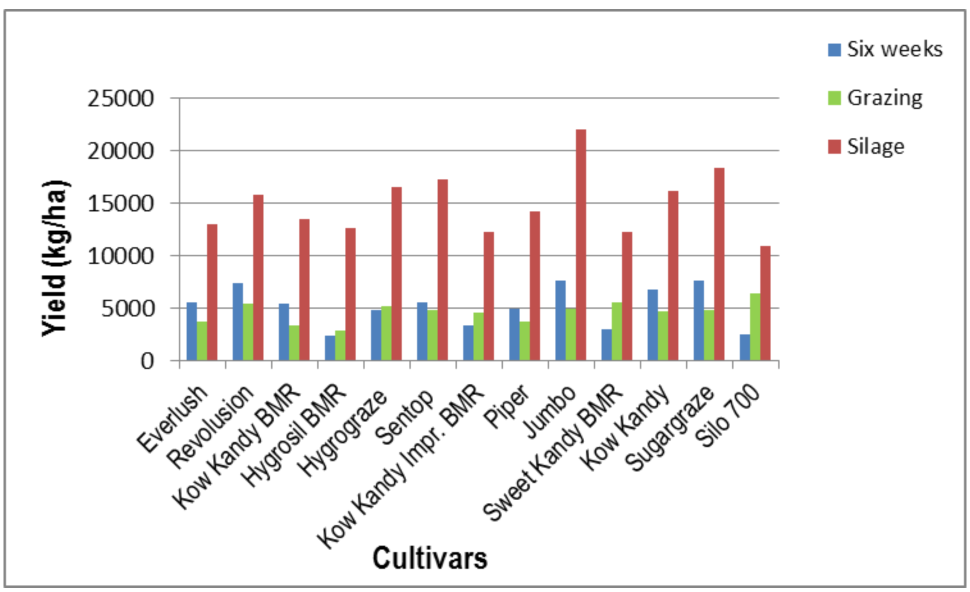

Figure 4.6: The influence of defoliation treatment on the TDM production (kg/ha) of forage sorghum cultivars planted in January

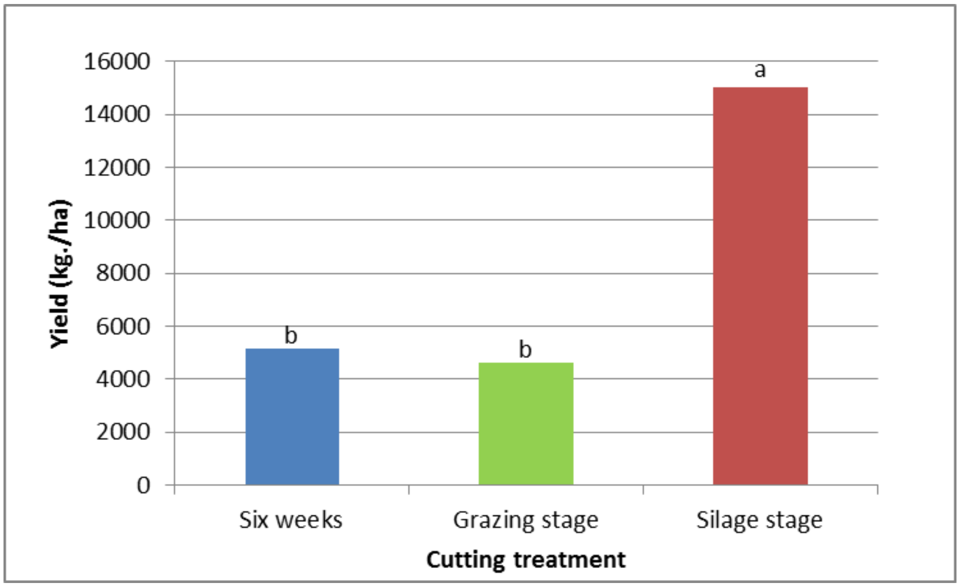

Figure 4.7: TDM production (kg/ha) of cultivars planted in January as influenced by defoliation treatments

Roman letters (a, b) indicate significant difference

4.1.3.2 DM production of plants planted at DWD in January and defoliated every six weeks (Dt 1).

On the experimental plots that were planted in January and defoliated six weekly (Dt 1), three cuts were achieved for the season. According to the statistical analyses in Addendum A5, significant differences ($P \leq 0.001$) in DM production were observed for cultivars and cuts as the main treatment. The interaction between cuts and cultivars was non-significant ($P \leq 0.111$). However, significant trends were observed when the results were compared with the Fisher's protected LSD of 1973.1 for the interaction and 547.2 for the cutting date.

The production trends, as influenced by cultivars, were classified in production groups (per separate cuts) that are shown in different colours in Table 4.7. (Red = high production group, light brown = medium high production group, orange = medium low production group and yellow = low production group. The significant difference of individual cultivars between cuts are shown with the following symbols <, = and >).

The DM distribution of cultivars in Cut 1 ranged from 188 kg/ha to 2451 kg/ha with Kow Kandy as the highest producer and Silo 700 the lowest producer. DM production of Kow Kandy and Jumbo were the highest (red in Table 4.7), but was not significantly higher than the cultivars coloured orange in the table. However Kow Kandy and Jumbo produced significantly higher than Silo 700 (yellow in Table 4.7).

Table 4.7: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated every six weeks

Forage sorghum Cultivars	Cut 1 01 Mar	Cut 2 18 Apr	Cut 3 04 Jun
Everlush	1413 ab <	4040 bcde >	96 a
Revolusion	1672 ab <	5633 ab >	137 a
Kow Kandy BMR	1070 ab <	4216 bc >	158 a
Hygrosil BMR	784 ab =	1467 f =	103 a
Hygrograze	1012 ab <	3737 bcde >	117 a
Sentop	1585 ab <	3892 bcde >	117 a
Kow Kandy Impr. BMR	1007 ab =	2220 def >	103 a
Piper	1002 ab <	3672 bcde >	247 a
Jumbo	2432 a <	5027 ab >	220 a
Sweet Kandy BMR	849 ab =	2076 ef >	89 a
Kow Kandy	2451 a =	4130 bcd >	144 a
Sugargraze	842 ab <	6684 a >	110 a
Silo 700	188 b <	2263 cdef >	69 a
Mean	1254 [b]	3774 [a]	131 [c]
LSD (P≤ 0.05) Interaction Cv X Cut: 1973.1 Cut: 547.2 Coefficient of variation = 70.0% < > shows significant difference between cuts (LSD = 1973.1) = shows no significant difference Values with the same Roman letter do not differ significantly			

The DM production of cultivars in Cut 2 ranged from 1467 kg/ha to 6684 kg/ha with Sugargraze as the highest producer and Hygrosil BMR the lowest producer (yellow). When comparing the results in Cut 2 with the Fischer's protected LSD of 1973, significant differences were observed, as shown with Roman letters in Table 4.7. The different cultivars were divided into four DM productions groups, shown in different colours in the table. Sugargraze, Revolusion and Jumbo produced higher than 5000 kg/ha (red) and that was significantly higher than the DM production of Kow Kandy Improved BMR, Sweet Kandy BMR and Silo, which produced between 2000 and 2300 kg/ha (orange in table). Hygrosil BMR produced 1467 kg/ha (yellow in table) and that was not significantly lower than the orange group. The rest of the cultivars formed a medium high production group that ranged between 3672 kg/ha and 4216 kg/ha (light brown). This production group differed significantly from the production of Sugargraze, but non-significantly from that of Revolution and Jumbo.

In Cut 3 the DM production of cultivars ranged from 69 kg/ha to 247 kg/ha, with Piper the highest producer and Silo 700 the lowest producer.

The DM production in Cut 2 was, on average, significantly higher than in Cut 1 and Cut 3. Jumbo, Revolusion, Sentop, Everlush, Kow Kandy BMR, Hygrograze, Piper, Sugargraze and Silo 700 followed the same trend, with the highest DM production in Cut 2. These nine cultivars produced relative low in the beginning of the season (March), improved in production during the second cut (mid-April) and declined fast in production towards June.

In the case of Kow Kandy, Kow Kandy Improved BMR, Sweet Kandy BMR and Hygrosil BMR the difference in DM production between Cuts 1 and 2 did not differ significantly, although the production trend was the same as in the case of the other nine cultivars (Cut 2 higher than Cu1 and Cut 3). This seasonal production trend is shown in Figure 4.8 and illustrates also that planting forage sorghum in January resulted in a short production cycle from March to April.

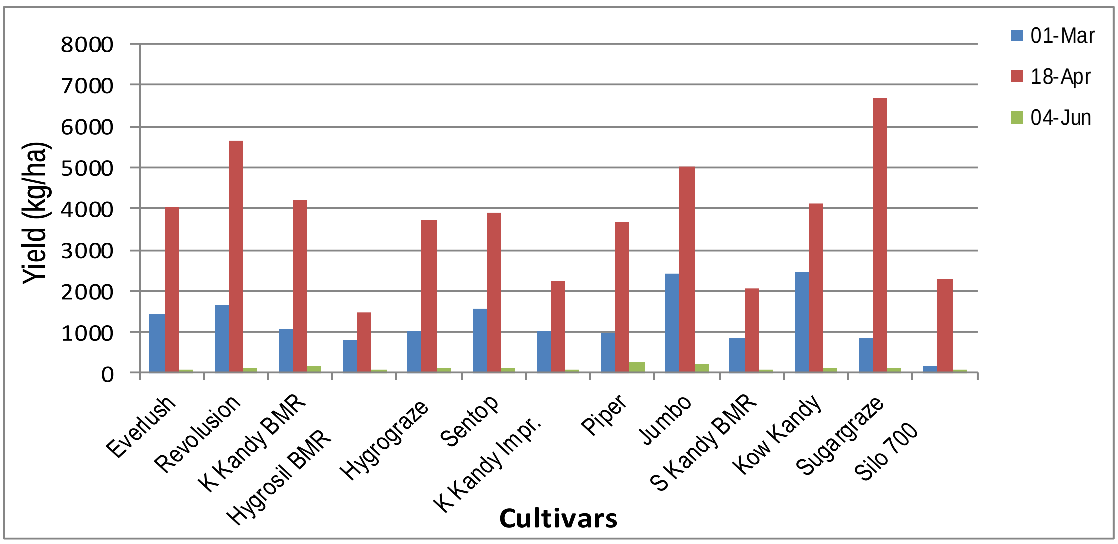

Figure 4.8: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated every six weeks

The average production on the three cutting dates for the 6 weeks defoliation treatment is shown in Figure 4.9. When comparing these DM productions with the Fisher's protected LSD of 547.2 (Table 4.6), the average production of Cut 1 (early-March) was 1254 kg/ha, for Cut 2 (mid-April) 3774 kg/ha and for Cut 3 (early-June) 131 kg/ha. All the cuttings were significantly different from each other, with Cut 2 the highest and Cut 3 the lowest.

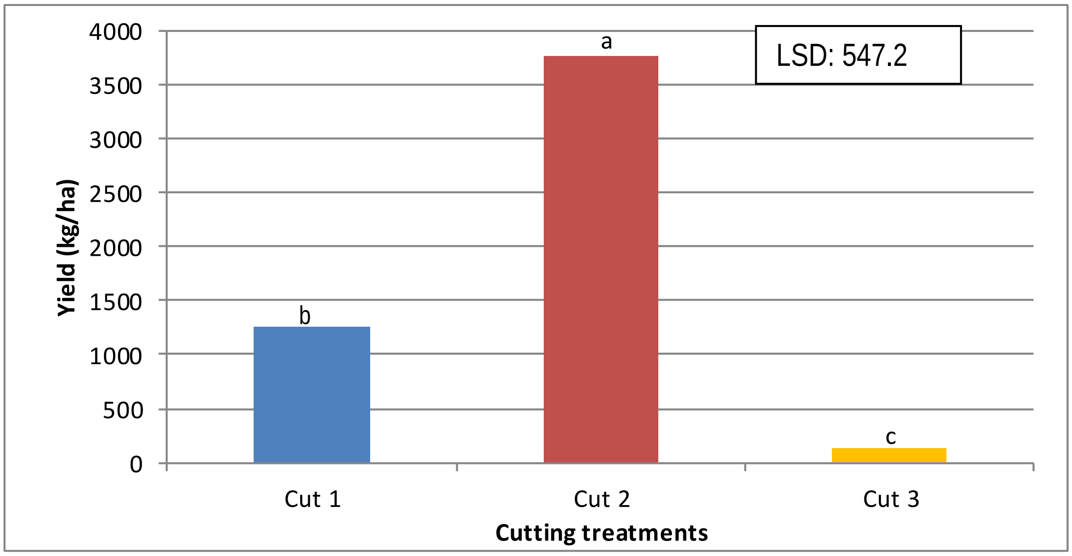

Figure 4.9: The average six weekly DM production (kg/ha) of forage sorghum cultivars as influenced by cutting dates

Roman letters (a, b, c) indicate significant difference

4.1.3.3 DM production when defoliated at the grazing stage (Dt 2).

The ideal grazing height for forage sorghum was taken as ± 800 mm and the plants were defoliated at that height to measure DM production. The cultivars reached an average height of ± 800 mm at different dates and the different plots were not cut on the same day. For that reason, only total production (all cuts together) was analyzed statistically and shown in Table 4.6. A repetition of these results is shown in Table 4.8 and Figure 4.10 without statistical analyzes.

At this defoliation treatment the TDM production of cultivars ranged between 2903 kg/ha and 6425 kg/ha with Silo 700 the highest and Hygrosil BMR the lowest producer. Subjectively, four production groups were identified: Red = > 6000 kg/ha (high producers), light brown = 4500 kg/ha to 5999 kg/ha (medium high producers), orange = 3000 kg/ha to 4499 kg/ha (medium low producers), yellow = < 3000 kg/ha (low producers).

- High producers: > 6000 kg/ha, red: Hygrosil BMR (6425 kg/ha).
- Medium high producers: 5000 kg/ha to 5999 kg/ha, light brown: Sweet Kandy BMR, Revolusion and Hygrograze BMR with a DM production of 5592 kg/ha, 5400 kg/ha and 5136 kg/ha, respectively.

- Medium low producers: 3000 kg/ha to 4999 kg/ha, orange: Jumbo, Sugargraze, Sentop, Kow Kandy, Kow Kandy Impr. BMR, Everlush, Piper and Kow Kandy BMR with DM productions ranging between 3329 kg/ha and 4973 kg/ha.
- Low producers: < 3000 kg/ha, yellow: Silo 700 (2903 kg/ha).

Table 4.8: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated at a grazing stage at DWD

Forage sorghum Cultivars	Total (kg/ha)
Silo 700	6425
Sweet Kandy BMR	5592
Revolusion	5400
Hygrograze	5136
Jumbo	4973
Sugargraze	4881
Sentop	4830
Kow Kandy	4661
Kow Kandy Impr. BMR	4544
Everlush	3767
Piper	3698
Kow Kandy BMR	3329
Hygrosil BMR	2903
Mean	4950

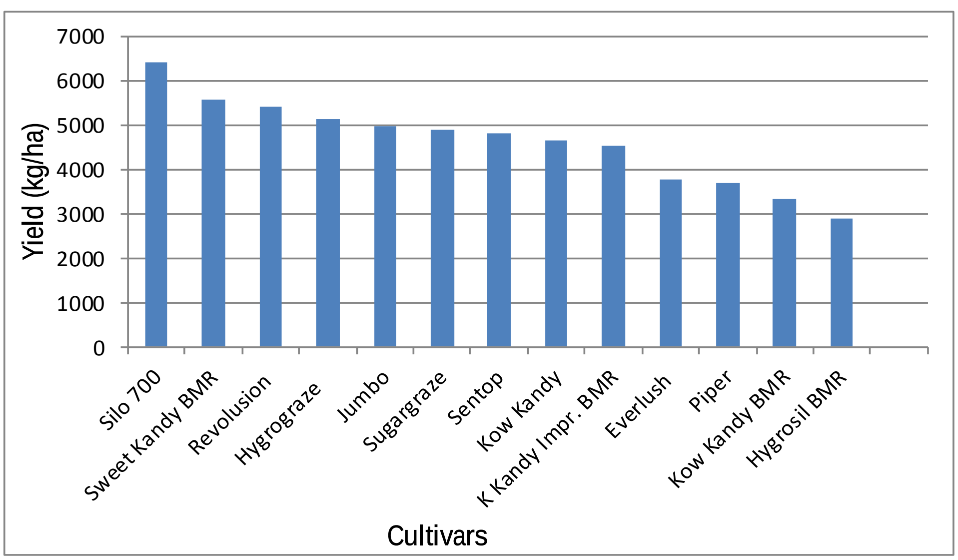

Figure 4.10: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated at a grazing stage

4.1.3.4 DM production at the silage stage (Dt 3)

The experimental plots that were planted in January were harvested at a silage stage on the 02 May and only one cut was achieved for the season. According to the statistical analyses in Addendum A6, there was no significant difference ($P \leq 0.304$) in the DM production of cultivars as the main treatment. However when comparing the results, as influenced by the interaction between cultivars and cutting treatment, with a Fisher's protected LSD of 8055.5, a trend of significant differences occurred. The differences in DM production are indicated with different colours in Table 4.9. Red > 20000 kg/ha (high producers), light brown = 14000 kg/ha to 19999 kg/ha (medium producers) and orange = < 14000 kg/ha (low producers).

Table 4.9: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated at a silage stage

Forage sorghum Cultivars	Cut 1 02 May
Jumbo	22100 a
Sugargraze	18350 a b
Sentop	17312 a b
Hygrograze	16570 a b
Kow Kandy	16155 a b
Revolution	15836 a b
Piper	14200 a b
Kow Kandy BMR	13499 b
Everlush	13058 b
Hygrosil	12613 b
Sweet Kandy BMR	12275 b
Kow Kandy Impr. BMR	12236 b
Silo 700	10991 b
Mean	15015
LSD ($P \leq 0.05$) Interaction; Cv X Cut: 8055.5 Coefficient of variation = 31.8% Values with the same Roman letter do not differ significantly	

Three production groups were identified:

- High producers were Jumbo only with the production of 22100 kg/ha.
- Medium producers were Sugargraze, Sentop, Hygrograze, Kow Kandy, Revolusion and Piper with productions ranging between 14200 kg/ha and 18350 kg/ha.

- Low producers were Kow Kandy BMR, Everlush, Hygrosil BMR, Sweet Kandy BMR, Kow Kandy Impr. BMR and Silo 700 with productions ranging between 10991 kg/ha and 13499 kg/ha.

Jumbo was the highest producer and not significantly different from the medium producing group, but significantly higher than the low producing group. The medium and the low producing groups were not significantly different from each other with Silo 700 being the lowest producer among all the cultivars.

Figure 4.11 is a more visual indication of the production trend.

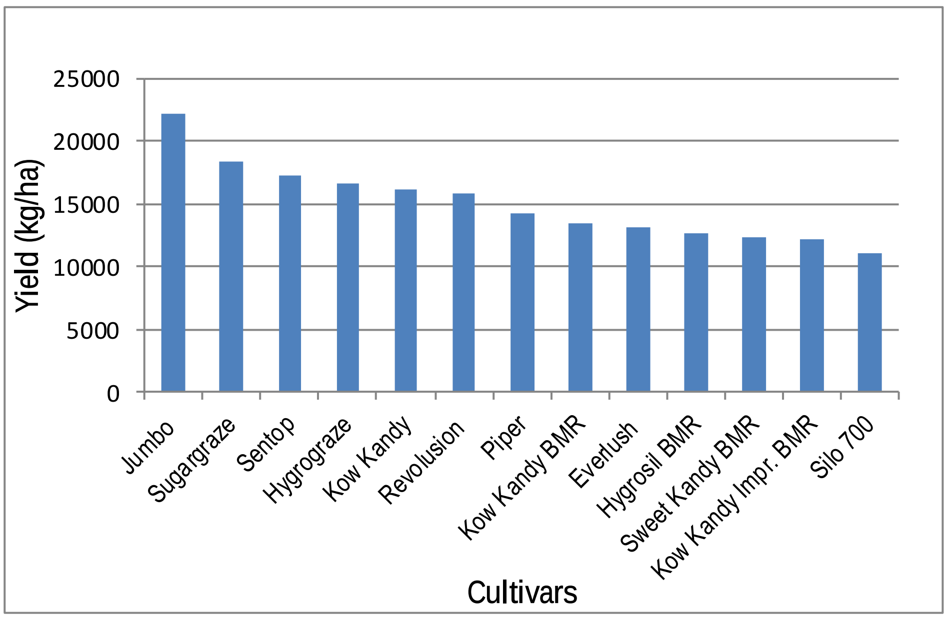

Figure 4.11: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated at a silage stage

<u>4.1.3.5 Summary of forage sorghum results when planted in January</u>

➢ Total DM production at the six weekly defoliation treatment (Dt 1)

Six weeks after planting (1 March), the average DM production of cultivars was 1254 kg/ha. The highest producers were Kow Kandy (2451 kg/ha) and Jumbo (2432 kg/ha) while the lowest producer was Silo 700 (188 kg/ha).

The six weeks regrowth (Cut 2, 18 April) was on average higher (3774 kg/ha) than the other two cuts. The cultivars that were identified as the highest producers (> 5000 kg/ha) were Sugargraze, Revolusion and Jumbo. The lowest producer was Hygrosil BMR (1467 kg/ha).

A further six weeks of regrowth (Cut 3, 04 June) produced, on average, 131 kg/ha which was the lowest. The DM production of cultivars was between 69 kg/ha for Silo 700 and 247 kg/ha for Piper, as the highest producer.

In terms of total production, the following five cultivars were the highest producers: Jumbo (7679 kg/ha), Sugargraze (7636 kg/ha), Revolusion (7442 kg/ha), Kow Kandy (6725 kg/ha) and Sentop (5594 kg/ha). The two lowest producers were: Silo 700 (2519 kg/ha) and Hygrosil BMR (2354 kg/ha).

- Defoliation at grazing stage (± 800 mm)

The DM production of cultivars, defoliated at a grazing stage, ranged between 2903 kg/ha and 6425 kg/ha with Silo 700 the highest and Hygrosil BMR the lowest producer. The highest producers (top five in ranking) were Silo 700, Sweet Kandy BMR, Revolusion, Hygrograze and Jumbo, with DM productions ranging between 4973 kg/ha and 6425 kg/ha. The three lowest producers were Piper (3698 kg/ha), Kow Kandy BMR (3329 kg/ha) and Hygrosil BMR (2903 kg/ha). Notice should be taken that Silo 700 was the lowest producer at the other two defoliation treatments

- Silage (Dt 3)

The DM production of the cultivars defoliated at a silage stage (Dt 3) ranged between 10991 kg/ha and 22100 kg/ha, with Jumbo producing higher than all the cultivars and Silo 700 the lowest. The high producers (top five in ranking) were Jumbo (22100 kg/ha), Sugargraze (18350 kg/ha), Sentop (17312 kg/ha), Hygrograze (16570 kg/ha), Kow Kandy (16155 kg/ha) and Revolusion (15835 kg/ha). The rest of the cultivars produced between 12236 kg/ha and 14200 kg/ha.

4.1.4 Results of the February planting date

As indicated in Paragraph 3.1.4 (Chapter 3), the 13 forage sorghum cultivars were subjected to three defoliation treatments: (i) six weekly (Dt 1), (ii) cut repeatedly when it reached a grazing stage (Dt 2) that was taken as (± 800 mm high) and (iii) at a silage stage (Dt 3).

Germination, growth and plant survival was low during this phase of the experiment, most probably because of the low rainfall in February, March and April which was in total 47.6 mm. The condition of some plots was so poor that only two replications instead of four were monitored. For this reason only total DM production was analyzed statistically, for the rest only trends are given.

4.1.4.1 Total DM production for the February planting date

According to the statistical analyses in Addendum A7, cutting treatment influenced results significantly ($P \leq 0.05$), as main treatment, as well as the interaction between cutting treatment and cultivars. Cultivars did not influence results significantly ($P \leq 0.154$). The results are shown in Table 4.10, Figure 4.12 and Figure 4.13.

Table 4.10: Total DM production (kg/ha) of forage sorghum cultivars planted in February

Forage sorghum Cultivars	Six weeks	Grazing	Silage
Everlush	1565 cd <	4215 a >	2502 abcd
Revolusion	1071 d =	1822 de =	2386 abcd
Kow Kandy BMR	2162 abcd =	2291 cde =	3582 a
Hygrosil BMR	2087 abcd <	3800 abc =	2651 abcd
Hygrograze	2172 abc =	2673 bcde =	1675 cd
Sentop	3148 ab =	2163 de =	3014 abc
Kow Kandy Impr. BMR	1578 cd <	4021 ab =	3176 abc
Piper	3274 a =	2127 de =	1357 d
Jumbo	1703 bcd =	1802 e =	2083 abcd
Sweet Kandy BMR	1251 cd <	3316 abcd =	1978 bcd
Kow Kandy	2655 abc =	1528 e =	3236 ab
Sugargraze	1092 d <	2867 abcde =	2738 abcd
Silo 700	1517 cd =	2257 e =	2502 abcd
Mean	1944 [b]	2683 [a]	2529 [a]

LSD ($P \leq 0.05$) Cv X Cut: 1512
Cut: 419
Coefficient of variation = 38.7%
< > shows significant difference between cuts
= shows no significant difference
Values with the same Roman letter do not differ significantly

When comparing the results, as influenced by cultivars, with Fishers protected LSD of 1512 within each cutting treatment, there was a trend of significant difference between DM productions of cultivars. The differences in TDM production are indicated with different colours in Table 4.10.

At the six weekly defoliation treatment the cultivars differed significantly from each other. The TDM production of the cultivars ranged between 1071 kg/ha and 3274 kg/ha with Piper the highest and Revolusion the lowest producer.

Three production groups were identified at six weeks (Dt 1) treatment:

- High producers: > 3000 kg/ha, Light brown: Piper (3274 kg/ha) and Sentop (3148 kg/ha).
- Medium producers: 1500 kg/ha to 2999 kg/ha, Orange: Kow Kandy, Hygrograze BMR, Kow Kandy BMR, Hygrosil BMR, Jumbo, Kow Kandy Impr. BMR, Everlush and Silo 700 with the DM production ranging between 1251 kg/ha and 2655 kg/ha.
- Low producers: < 1500 kg/ha, yellow: Sweet Kandy BMR (1251 kg/ha), Sugargraze (1092 kg/ha) and Revolusion (1071 kg/ha).

At the grazing stage the DM production of the cultivars ranged between 1528 kg/ha and 4215 kg/ha, with Everlush the highest and Kow Kandy the lowest producer. Subjectively, four production groups were identified: Red = > 4000 kg/ha (high producers), orange = 2800 kg/ha to 3999 kg/ha, yellow = 2000 kg/ha to 2799 kg/ha (medium producers) and green = < 2000 kg/ha (low producers).

- The high producers were Everlush and Kow Kandy Impr. BMR with a production of 4215 kg/ha and 4021 kg/ha, respectively.
- The medium high producers were Hygrosil BMR, Sweet Kandy BMR and Sugargraze, with productions ranging between 2867 kg/ha and 3800 kg/ha.
- The medium low producers were Hygrograze, Kow Kandy BMR, Silo 700, Sentop and Piper, with productions ranging between 2127 kg/ha and 2673 kg/ha.
- The low producers were Revolusion, Jumbo and Kow Kandy with productions of 1822 kg/ha, 1892 kg/ha and 1528 kg/ha, respectively.

The DM production of silage planted in February ranged between 1528 kg/ha and 4215 kg/ha with Kow Kandy BMR the highest and Piper the lowest producer. Four different DM production groups were identified: Light brown = > 3500 kg/ha (high producers), orange 3100 kg/ha to 3499 kg/ha (medium high producers), yellow = 1700 kg/ha to 3099 kg/ha (medium low producers) and light green < 1700 kg/ha (low producers).

- High producer: Kow Kandy BMR with a production of 3582 kg/ha.
- Medium high producers: Kow Kandy (3236 kg/ha) and Kow Kandy Improved BMR, with 3176 kg/ha.

- Medium low producers:, Sentop, Sugargraze, Hygrosil BMR, Everlush, Silo 700, Revolusion, Jumbo and Sweet Kandy BMR with productions ranging between 1978 kg/ha and 3104 kg/ha.
- Low producers: Hygrograze and Piper with a productions of 1675 kg/ha and 1357 kg/ha respectively.

According to Table 4.10 and Figure 4.12, cultivars responded differently to the cutting treatments. Cultivars such Everlush, Hygrosil BMR, Hygrograze, Kow Kandy Improved BMR, Sweet Kandy BMR and Sugargraze yielded the highest at the grazing stage. At the silage stage, Revolusion, Kow Kandy BMR, Jumbo, Kow Kandy and Silo 700 yielded the highest, while Sentop and Piper produced higher at six weeks.

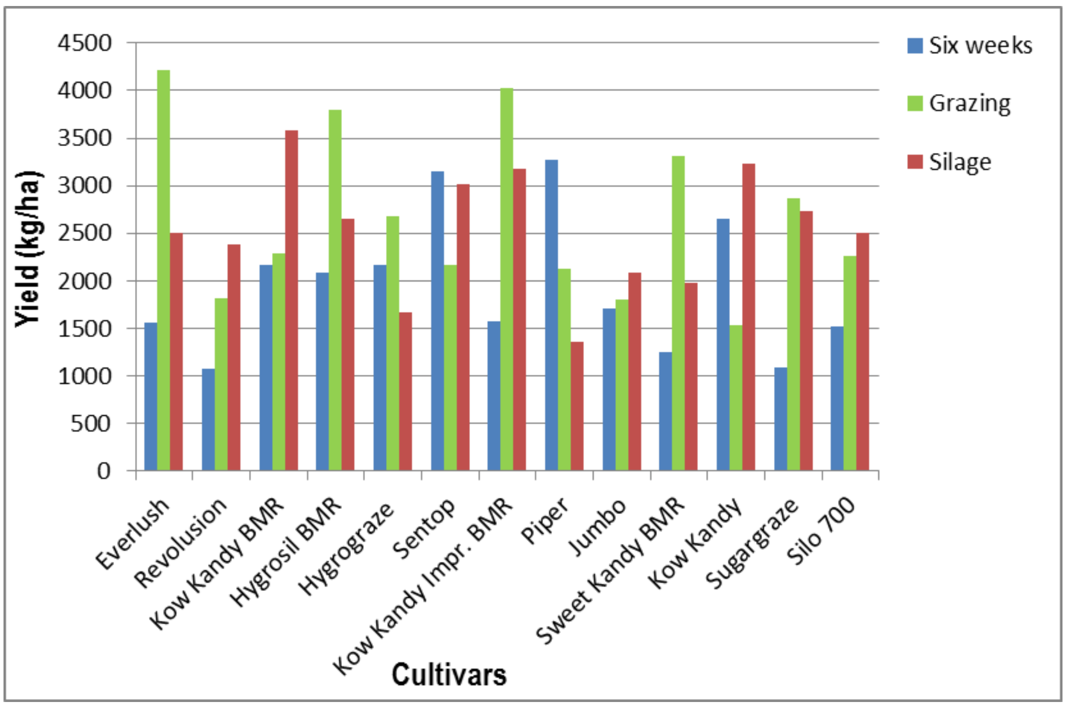

Figure 4.12: The influence of defoliation treatment on the TDM production (kg/ha) of forage sorghum cultivars planted in February

The influence of defoliation treatments (as main effect) on the total DM production is shown in Table 4.10 and Figure 4.13. When comparing the results, as influenced by cutting treatment with Fishers protected LSD of 419, the average production was 2529 kg/ha at a silage stage, 2683 kg/ha at a grazing stage and 1944 kg/ha at a six weeks stage. The TDM production at the grazing stage was the highest amongst the three cutting treatments. It was significantly higher than that of the six weeks defoliation treatment, but not significantly different from the TDM production of the silage stage.

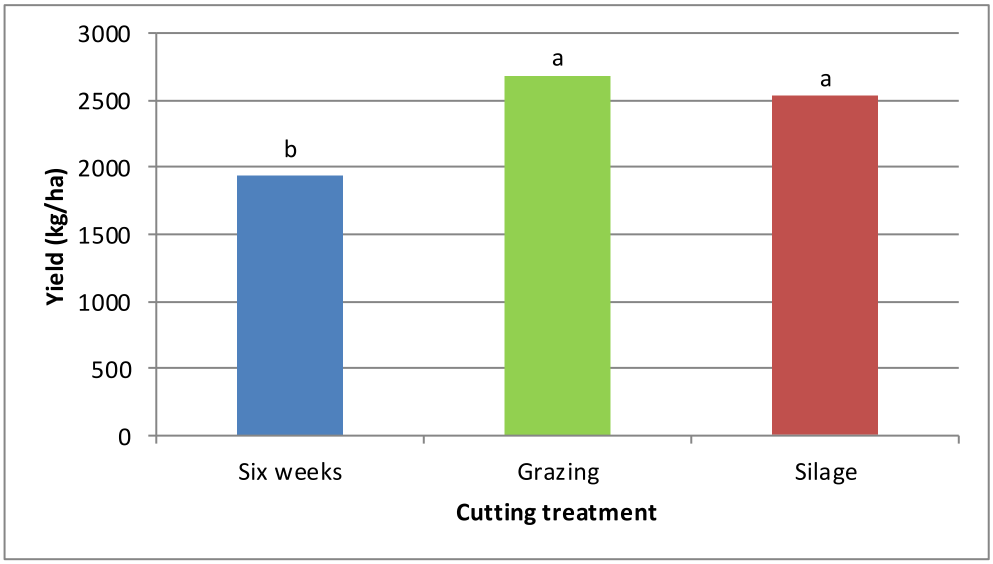

Figure 4.13: TDM production (kg/ha) of cultivars planted in February as influenced by defoliation treatments

Roman letters (a, b) indicate significant difference

4.1.4.2 DM production of plants planted at DWD in February and defoliated every six weeks (Dt 1)

The TDM production at the six weekly (Dt 1) treatment, planted in February, was discussed earlier. Three cuts were achieved for the season on this treatment. This data was not analyzed statistically, for reasons explained earlier, and the production trend per cut is shown in Table 4.11, Figure 4.14 and Figure 4.15.

The DM production in Cut 1 ranged between 574 kg/ha and 2007 kg/ha, with Sentop the highest and Sugargraze the lowest producer. The different DM productions were grouped in different production groups. They are shown in different colours in Table 4.10. Sentop was the highest producer with 2007 kg/ha (light brown). Sweet Kandy BMR, Everlush, Revolusion and Sugargraze produced between 574 kg/ha and 942 kg/ha and they can be classified as low producers (yellow). The rest of the cultivars formed an intermediate (medium) production group with DM productions ranging between 1001 kg/ha and 1609 kg/ha (orange).

In Cut 2, production of cultivars ranged between 315 kg/ha and 2027 kg/ha, with Piper the highest and Sweet Kandy BMR the lowest producer. The DM production in Cut 3 ranged between 12 kg/ha for Sweet Kandy BMR and 119 kg/ha for Piper.

Table 4.11: DM production (kg/ha) of forage sorghum cultivars planted in February and defoliated every six weeks

Forage sorghum Cultivars	Cut 1 In Apr	Cut 2 In May	Cut 3 In Jun
Everlush	814	714	37
Revolusion	607	409	55
Kow Kandy BMR	1196	920	46
Hygrosil BMR	1609	444	34
Hygrograze	1483	655	34
Sentop	2007	1030	111
Kow Kandy Impr. BMR	1114	430	34
Piper	1255	1900	119
Jumbo	1001	618	84
Sweet Kandy BMR	942	297	12
Kow Kandy	1604	949	102
Sugargraze	574	484	34
Silo 700	1185	315	17
Mean	1184	705	55

These trends are shown more visually in Figure 4.14.

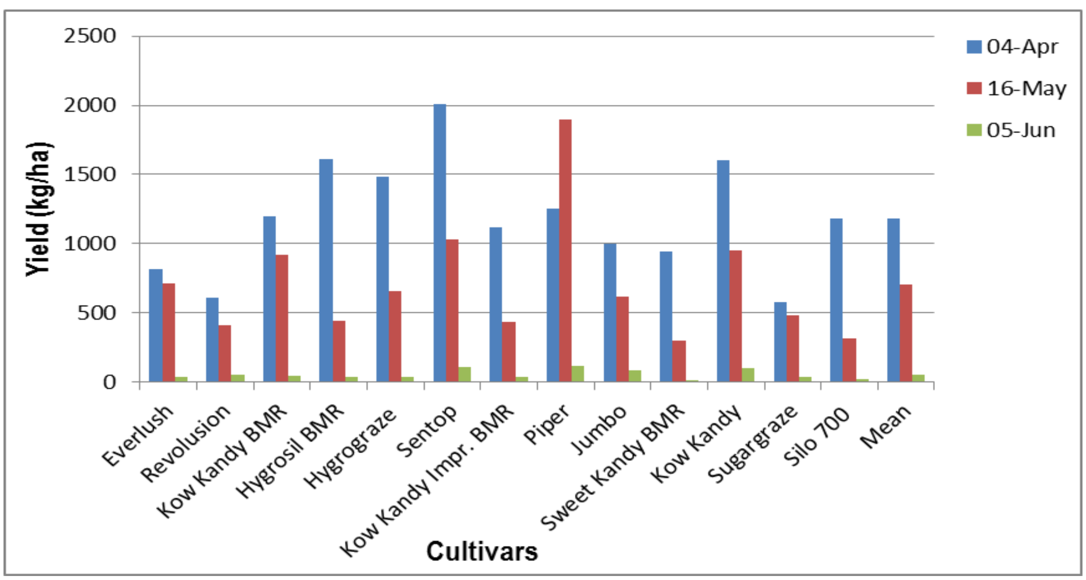

Figure 4.14: DM production (kg/ha) of forage sorghum cultivars planted in February and defoliated every six weeks

The effect of defoliation treatments on the average DM production at different cuts are shown in Figure 4.15. On average, the production in Cut 1 (early-April) was 1219 kg/ha and higher than the other two cuts, followed by Cut 2 (mid-May) with an average production of 717 kg/ha. Cut 3 (early-June) was the lowest with an average production of 55 kg/ha.

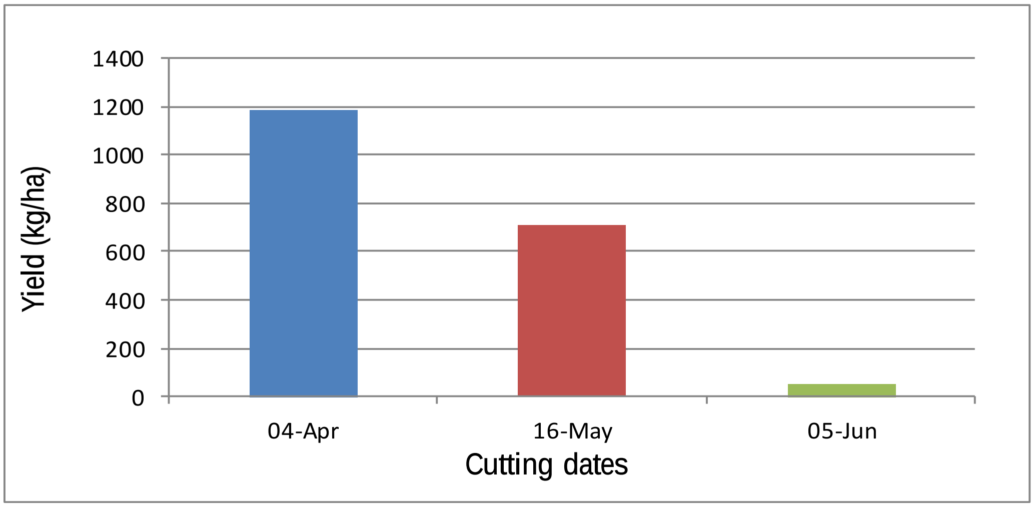

Figure 4.15: The average six weekly DM production (kg/ha) of forage sorghum cultivars as influenced by cutting dates

4.1.4.3 The DM production when defoliated at a grazing stage (Dt 2) and the silage state (Dt 3)

The TDM production for these two treatments was discussed in Paragraph 4.1.4.1. Results obtained in separate cuts cannot be discussed for reasons mentioned earlier.

4.1.4.5 Summary of forage sorghum results when planted in February

- Six weekly cut (Dt 1) DM production

The conclusions can be made according to the results in Tables 4.10 and 4.11, when comparing the DM production of cultivars planted in February at DWD and defoliated at a six weekly interval. Six weeks after planting (01 April), the average DM production of cultivars was 1184 kg/ha and it was higher than the other two cuts. The highest producers were Sentop (2007 kg/ha), followed by Hygrosil BMR (2432 kg/ha), while the lowest producer was Sugargraze (574 kg/ha).

At the six weeks regrowth (Cut 2, 16 May) the highest producer was Piper (1900 kg/ha), followed by Sentop (1030 kg/ha). The lowest producer was Sweet Kandy BMR (297 kg/ha). The DM productions of the rest of the cultivars ranged between 315 kg/ha and 949 kg/ha. The average DM production of cultivars was 705 kg/ha.

A further six weeks of regrowth (Cut 3, 05 June) produced, on average, 55 kg/ha which was the lowest. The DM production of cultivars was between 12 kg/ha for Sweet Kandy BMR and 119 kg/ha for Piper as the highest producer.

In terms of total production the following cultivars were the highest producers: Sentop (3148 kg/ha), Piper (3274 kg/ha), Kow Kandy (2655 kg/ha), Hygrograze (2172 kg/ha) and Kow Kandy BMR (2162 kg/ha). The three lowest producers were Sweet Kandy BMR (1251 kg/ha), Sugargraze (1092 kg/ha) and Revolusion (2354 kg/ha).

- Defoliation at grazing stage (± 800 mm)

According to the results in Table 4.10 the following conclusion can be made:
The DM production of cultivars, when defoliated at a grazing stage ranged between 1528 kg/ha and 4215 kg/ha with Everlush the highest and Kow Kandy the lowest producer. The average DM production of cultivars was 2683 kg/ha. The highest producers (top five in ranking) were Everlush, Kow Kandy Impr. BMR, Hygrosil BMR, Sweet Kandy BMR and Sugargraze. The DM productions ranged between 2867 kg/ha and 4215 kg/ha. The three lowest producers were Revolusion (1822 kg/ha), Jumbo and Kow Kandy Impr. BMR (1528 kg/ha).

- Silage (Dt 3)

According to the results in Table 4.10, the DM production of the cultivars defoliated at a silage stage (Dt 3) ranged between 1357 kg/ha and 3585 kg/ha with Kow Kandy BMR producing higher than all the cultivars and Piper the lowest. The high producers (top five in ranking) were Kow Kandy BMR (3585 kg/ha), Kow Kandy (3236 kg/ha), Kow Kandy Impr. BMR (3176 kg/ha), Sentop (3014 kg/ha) and Sugargraze (2738 kg/ha). The rest of the cultivars produced between 1765 kg/ha and 2651 kg/ha. The average DM production of all cultivars was 2529 kg/ha.

4.2 RESULTS AT NOOITGEDACHT (NGT), ERMELO, MPUMALANGA

4.2.1 SOIL ANALYSIS

Before the experiment started, soil samples were taken and analyzed. The results are shown in Table 4.12.

Table 4.12: Soil analysis of soil on the experimental site

Soil depth	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	pH
Top soil (0-15 cm)	19	53	463	136	28	5.8

Forage sorghum practically grows well on a large variety of sandy to clay soils and can be planted more successfully on marginal soils than other crops, like maize. It adapts well to soil with a pH of 4.5 to 6.5 Donaldson (2001). The soil pH at the experimental site was 5.8 (which was in the suggested range). The P level of the soil at the experimental site was 19 mg/kg, which were higher than the recommended concentration of 15 mg/kg. The K level at the experimental site was 53 mg/kg which was lower than the required level for forage sorghum (80 mg/kg to 100 mg/kg).

4.2.2 METEOROLOGICAL DATA

The seasonal temperature (maximum and minimum), rainfall and frost days were recorded at the Nooitgedacht ADC during the experimental period and the results are presented in Table 4.13.

According to the meteorological data in Table 4.13, the total rainfall recorded from July to December 2006 was 361.9 mm. That was lower than the long term average (LTA) of 381.4 mm for the same period. The total rainfall recorded from January to June 2007 was 234.5 mm and that was lower than the LTA of 321.9 mm for the same months. The rainfall in August (53.5 mm) and October (25 mm) was adequate for soil preparation and planting while the good rainfall of November (125.4 mm) and December (158 mm) assured fast germination and early production. The 23.5 mm in June and 53.5 mm in August during the experiment were not normal, as compared to the LTA of 7.8 mm and 12.9 mm for the same months.

According to the meteorological results in Table 4.13 and meteorological data in Table 3.3, the mean maximum temperatures recorded for December 2006, January, February and March 2007 (summer season) were 26.1°C, 27.7°C, 24.1°C and 25.9°C, respectively. These temperatures were relatively high, compared to the LTA of the same months. The mean minimum temperatures recorded in summer were also higher than the LTA for the same months. The mean minimum and maximum temperature recorded in June, July and August (winter) during the experiment were higher than the LTA of the same months, except for the August maximum temperature, which was lower. These results show that it was a relatively warm winter, compared with the LTA. These temperatures had an influence on optimum growth and good production.

Table 4.13: Meteorological data for 2006/2007 at the Nooitgedacht ADC, Ermelo

(Source: ISCW, Agromet Section, Private Bag X 79, Pretoria 0001)

2006	Frost (days)	Rain (mm)	Temp Min (ºC)	Temp Max (ºC)
Jul	3	0.0	2.7	20.2
Aug	1	53.5	3.7	18.2
Sep	0	0.0	6.7	23.4
Oct	0	25.0	11.4	25.6
Nov	0	125.4	12.5	24.9
Dec	0	158.0	14.6	26.1
2007				
Jan	0	108.8	14.0	27.7
Feb	0	19.7	13.0	24.1
Mar	0	68.5	11.8	23.0
Apr	0	14.0	9.2	22.9
May	8	0.0	2.0	20.3
Jun	5	23.5	1.7	17.8
Total		596.4		

KEY NOTES :

Rain	mm/mnth Rainfall	
FD days	Frost Days	
Tmax	ºC	Daily Maximum Temperature
Tmin	ºC	Daily Minimum Temperature

4.2.3. RESULTS: DECEMBER PLANTING DATE

As indicated in Paragraph 3.2.4 (Chapter 3), the 12 forage cultivars were subjected to three defoliation treatments: (i) six weekly (Dt 1), (ii) cut repeatedly when it reached a grazing stage (Dt 2) that was taken as (±800 mm high) and (iii) at a silage stage (Dt 3). The results of the three different defoliation treatments were analyzed separately.

4.2.3.1. The DM production (kg/ha) of forage sorghum defoliated every six weeks (Dt 1)

The six weekly defoliation treatment (Dt 1) resulted in three cuts for the season and results are shown in Table 4.14 and Figure 4.16. According to the statistical analyses in Addendum B1, significant differences (P≤ 0.001) in DM production were observed for cultivars and cuts, as the main treatments. The interaction between cuts and cultivars was also significant (P≤0.028). Significant differences were also observed when results were compared with a Fischer's protected LSD of 1376.9. The influence of treatments (LSD = 1376.9) on DM production is shown in different colours in Table 4.14. Light brown = high production group, orange = medium production group and yellow = low production group. The colour codes were used to compare the production differences between individual cultivars (per cutting date), while the significant differences between cuts (per cultivar) are shown with the symbols <, = and >).

Table 4.14: DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated every six weeks

Forage sorghum Cultivars	Cut 1 08 Feb	Cut 2 22 Mar	Cut 3 07 May
Everlush	1286 a <	4079 bc>	1323 a
Revolusion	1211 a <	3683 cd >	1342 a
Kow Kandy BMR	1432 a <	3626 cd >	1412 a
Hygrosil BMR	881 a =	1916 e =	1188 a
Hygrograze	1381 a =	2067 e =	1711 a
Sentop	2044 a <	4136 bc>	1543 a
Kow Kandy Impr. BMR	969 a =	2097 e =	1264 a
Piper	1224 a <	5150 ab >	2295 a
Jumbo	1501 a <	5574 a >	1433 a
Sweet Kandy BMR	871 a <	2314 de >	1419 a
Kow Kandy	1226 a <	4389 abc>	1744 a
Sugargraze	1146 a <	4008 bc>	1865 a
Mean	1264 ^{b}	3587 ^{a}	1545 ^{b}

LSD (P≤ 0.001) Interaction; Cv X Cut: 1376.9
Cut: 397.5
Coefficient of variation = 45.8%
<> shows significant difference between cuts (LSD= 1376.9)
= shows no significant difference
Values with the same Roman letter do not differ significantly

The DM production in Cut 1 ranged between 871 kg/ha (Sweet Kandy BMR) and 2044 kg/ha (Sentop), but no significant differences occurred. The DM production in Cut 2 ranged from 1961 kg/ha in the case Hygrosil BMR to 5576 kg/ha (Jumbo).

When comparing the results in Cut 2 with the Fischer's protected LSD of 1376.9, significant differences were observed as shown with different Roman letters in the table. Three different DM productions groups were identified: Piper and Jumbo produced more than 5000 kg/ha (light brown) which was significantly higher than the DM production of Sweet Kandy BMR, Kow Kandy Improved BMR, Hygrograze and Hygrosil BMR (yellow). The rest of the cultivars formed an intermediate production group (3626 kg/ha to 4389 kg/ha), shown in orange in the table.

The DM production of cultivars in Cut 3 varied from 1188 kg/ha (Hygrosil BMR) to 2295 kg/ha (Piper). DM production of the cultivars in Cut 3 did not differ significantly from each other (yellow).

On average, the DM production in Cut 2 was significantly higher (LSD = 397.5) than that in Cut 1 and Cut 3. Everlush, Revolusion, Kow Kandy BMR, Sentop, Piper, Jumbo, Sweet Kandy BMR, Kow Kandy and Sugargraze followed the same trend, with the highest DM production in Cut 2. The DM production of Hygrosil BMR, Hygrograze and Kow Kandy Improved BMR did not differ significantly between cuts. The seasonal production of the cultivars is shown in Figure 4.16.

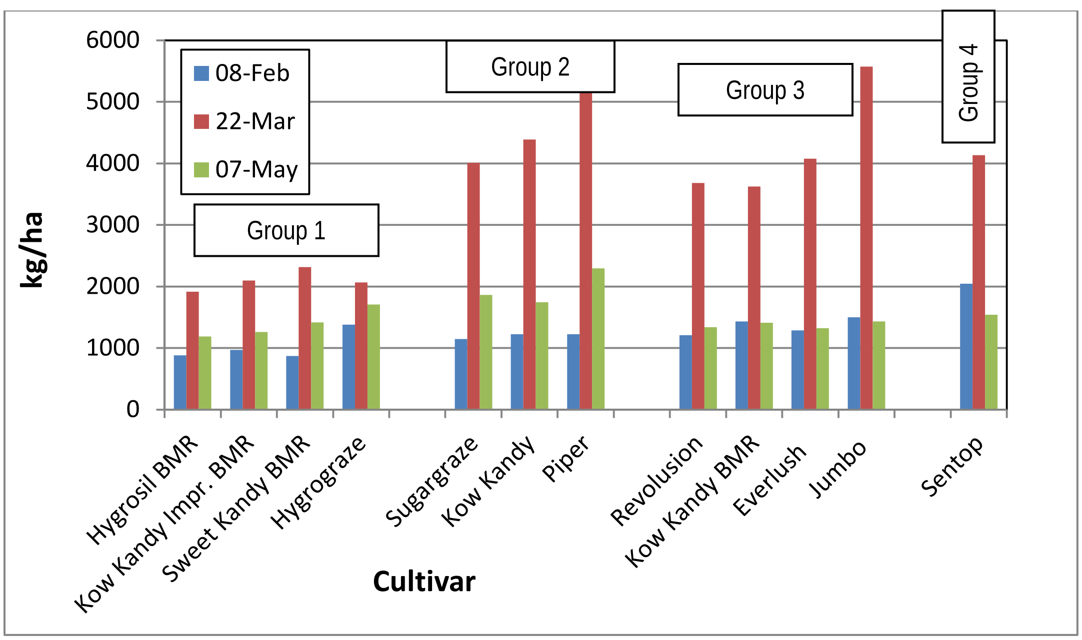

Figure 4.16: DM production (kg/ha) of forage sorghum cultivars planted in December at NGT and defoliated every six weeks

All cultivars produced higher in the second Cut and the significance of that is shown and discussed in Table 4.14. Four distinct production groups could be identified in Figure 4.16:

Group 1: Low producers that produced higher in Cut 3 than Cut 2 (mid/late season producers)

Group 2: High producers that produced higher in Cut 3 than Cut 2 (mid/late season producers)

Group 3: High producers with no significant difference between Cut 3 and Cut 2 (mid-season)

Group 4: Medium producer that produced higher in Cut 2 than Cut 3 (early/mid-season producer)

The total rainfall from the planting date (in December) to Cut 1 (in February) was 187.8 mm (Table 4.13). Between 8 February 2007 and 22 March (Cut 1 to Cut 2) it was 88.2 mm and from 22 March to 7 May (Cut 2 to Cut 3) it was 14 mm. The low rainfall during the last mentioned period might have influenced the DM production of the last cut.

4.2.3.2. The DM production (kg/ha) of forage sorghum defoliated at the grazing stage (Dt 2)

An average height of ± 800 mm was taken as the most ideal grazing stage for cattle and the plants were cut at this height (see Par. 4.2.3.3). For the December planting, two cuts were achieved. The first was on 22 March and the second cut was on 18 April (lower than 800 mm) because the plants had reached the reproductive stage. According to the statistical analyses in Addendum B2, cultivars and cutting dates as main effects influenced results significantly ($P \leq 0.001$), as well as the interaction between cuts and cultivars ($P \leq 0.034$). The results are shown in Table 4.15 and Figure 4.16.

When comparing the results in Table 4.15 with a LSD of 1502, significant differences were observed, as shown in the table with different Roman letters. To understand the production trends clearly, the results were classified in production groups that are shown in the table in the following colours: (Red = high production group, light brown = medium high production group, orange = medium low production group and yellow = low production group. The colour codes are used to compare cultivars per cutting. Differences of individual cultivars between cuts are indicated with the symbols <, = and >).

Table 4.15: DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated at a grazing stage, at NGT

Forage sorghum Cultivars	Cut 1 22 Mar	Cut 2 18 Apr
Everlush	4574 b =	5158 ab
Revolusion	4225 bc=	5402 ab
Kow Kandy BMR	2468 d <	4245 bc
Hygrosil BMR	1454 d =	2670 d
Hygrograze	2792 d =	4216 bc
Sentop	4903 ab =	4860 ab
Kow Kandy Impr. BMR	2146 d <	5109 ab
Piper	1883 d <	5948 a
Jumbo	3927 c <	5794 a
Sweet Kandy BMR	2532 d =	3235 cd
Kow Kandy	3745 c =	4901 ab
Sugargraze	2410 d <	4635 ab
Mean	3088 [b]	4681 [a]

LSD (P≤ 0.034) Interaction; Cv X Cut: 1502
Cut: 434
Coefficient of variation = 27%
<> shows significant difference between cuts (LSD= 1502)
= shows no significant difference
Values with the same Roman letter do not differ significantly

The DM production in Cut 1 ranged from 1454 kg/ha for Hygrosil BMR to 4903 kg/ha for Sentop, whereas in Cut 2, it ranged from 2670 kg/ha for Hygrosil BMR to 5948 kg/ha for Jumbo.

The DM production on 22 March (first defoliation) could be classified as follows:

- Medium-high producers (4500 kg/ha to 5500 kg/ha, light brown in table): Sentop, Everlush and Revolusion with 4903 kg/ha, 4574 kg/ha and 4225 kg/ha, respectively.
- Medium–low producers (3000 kg/ha to 4500 kg/ha, orange in table): Jumbo (3927 kg/ha) and Kow Kandy (3745 kg/ha).
- Low producers (< 3000 kg/ha, yellow in table): Hygrograze (2792 kg/ha), Sweet Kandy BMR (2532 kg/ha), Kow Kandy BMR (2468 kg/ha), Sugargraze (2410 kg/ha), Kow Kandy Impr. BMR (2146 kg/ha), Piper (1883 kg/ha) and Hygrosil BMR (1454 kg/ha).

The DM production on 18 April (second defoliation) could be classified as follows:

- High producers (>5500 kg/ha, red in table): Piper (5948 kg/ha) and Jumbo (5794 kg/ha)

- Medium-high producers (4500kg/ha to 5500 kg/ha, light brown in table): Revolusion (5402 kg/ha), Everlush (5158 kg/ha), Kow Kandy Impr. BMR (5109 kg/ha), Kow Kandy (4910 kg/ha), Sentop (4860 kg/ha) and Sugargraze (4635 kg/ha).
- Medium-low producers (3000 kg/ha to 4500 kg/ha, orange in table): Kow Kandy BMR (4245 kg/ha), Hygrograze (4216 kg/ha) and Sweet Kandy BMR (3235 kg/ha).
- Low producers (> 3000 kg/ha, yellow in table): Hygrosil BMR (2670 kg/ha).

By cutting regularly at a grazing height of ±800 mm, production was, on average, significantly higher (LSD = 434) in April (Cut 2) than in March (Cut 1) (Figure 4.17) with production values of 4681 kg/ha and 3088 kg/ha, respectively.

A visual summarized version of results in Table 4.15 is given in Figure 4.17. Waiting until March for the plants to reach a grazing height of ± 800 mm, indicated that Everlush, Revolution and Sentop were the highest producers (< 4000 t/ha) at this stage. The regrowth of these three cultivars was also high (± 5000 t/ha). Piper and Kow Kandy Improved BMR were "slow starters" but produced more than 5000 t/ha in April. Hygrosil BMR was all over a low producer, while the rest of the cultivars were high producers with their highest contribution in April.

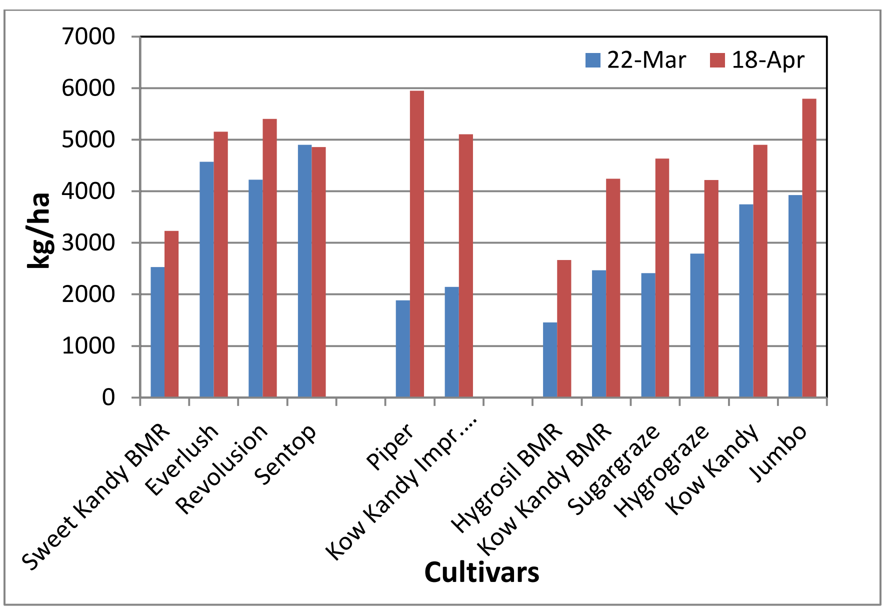

Figure 4.17: DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated at a grazing stage

4.2.3.3 DM production at the silage stage (Dt 3)

Only one cut was achieved for the season and was done on 17 April. According to the statistical analyses in Addendum B3, there was no significant difference (P≤0.188) in DM production between the cultivars, however when compared with a LSD of 5637,differences were identified, as shown with different Roman letters and colours in Table 4.16.

Table 4.16: DM production (kg/ha) of forage sorghum cultivars planted in December and defoliated at a silage stage

Forage sorghum Cultivars	Cut 1 17 April
Jumbo	15151 a
Sentop	14695 ab
Sugargraze	14604 ab
Revolusion	13558 abc
Kow Kandy	13471 abc
Sweet Kandy BMR	11631 abc
Everlush	11348 abc
Hygrograze	10653 abc
Kow Kandy BMR	10449 abc
Hygrosil BMR	9305 bc
Piper	8966 c
Kow Kandy Impr. BMR	8436 c
Mean	11856
LSD (P≤ 0.188);Cv: 5637 Coefficient of variation = 33.0% Values with the same Roman letter do not differ significantly	

The DM production could be classified in four production groups:

Red = > 15000 kg/ha, light brown = 14000 kg/ha to 14999 kg/ha, orange = 10000 kg/ha to 13999 kg/ha and yellow = < 10000 kg/ha.)

- Highest producer was Jumbo with 15151 kg/ha.
- Medium-high producers included Sentop (14695kg/ha) and Sugargraze (14604kg/ha).
- Medium-low producers included Revolusion (13558 kg/ha), Kow Kandy (13471 kg/ha). Sweet Kandy BMR (11631 kg/ha), Everlush (11348 kg/ha), Hygrograze (10653 kg/ha) and Kow Kandy BMR (10449 kg/ha).
- Low producers were Hygrosil BMR (9035 kg/ha), Piper (8966 kg/ha) and Kow Kandy Impr. BMR (8436 kg/ha).

4.2.3.4 Total Dry Matter (TDM) production for the December planting date

The total dry matter production of the cultivars at the different defoliation treatments are shown in Table 4.17, Figure 4.18.

According to the statistical analyses in Addendum B4, a significant difference (P≤0.001) in DM production was observed for cultivars and cutting treatment as the main treatments. The influence of interaction between cutting treatment and cultivars was non-significant (P≤0.790). However when comparing the results with a LSD of 4183.5 (within each cutting treatment), there was a trend of significance in the TDM production. The colour codes are used to compare cultivars per cutting treatment. Differences of individual cultivars between cuts are indicated with symbols <, = and >.

Table 4.17: Total DM production (kg/ha) of forage sorghum cultivars planted in December

Forage sorghum Cultivars	Six weeks (Dt 1)	Grazing stage (Dt 2)	Silage stage (Dt 3)
Everlush	6688 ab =	9732 a =	11348abcd
Revolusion	6236 ab =	9627 a =	13558abc
Kow Kandy BMR	6470 ab =	6713 ab =	10449 cd
Hygrosil BMR	3985 b =	4124 b =	9305 d
Hygrograze	5159 ab =	7008 ab =	10653 bcd
Sentop	7723 a =	9763 a <	14695 ab
Kow Kandy Impr. BMR	4330 b =	7255 ab =	8436 d
Piper	8669 a =	7831 ab =	8966 d
Jumbo	8508 a =	9721 a <	15151 ab
Sweet Kandy BMR	4604 ab =	5767 ab <	11631 abcd
Kow Kandy	7359 ab =	8646 a <	13471 abc
Sugargraze	7019 ab =	7045 ab <	14604 ab
Mean	6396^{c}	7769^{b}	11856^{a}

LSD (P≤ 0.790) Interaction; Cv X Cut: 4183.5
Cv: 2415.3
Cut: 1207.7
Coefficient of variation = 34.4%
<> shows significant difference between cuts (LSD= 4183,5)
= shows no significant difference
Values with the same Roman letter do not differ significantly.

At the six weekly defoliation treatment (Dt 1), the TDM production of the cultivars ranged between 3985 kg/ha and 8669 kg/ha. The average was 6396 kg/ha, which was significantly lower than the averages of the other two cutting treatments. Three production groups were identified at the six weeks (Dt 1) treatment:

- High producers: > 7500 kg/ha, light brown: Piper (8669 kg/ha), Jumbo (8508 kg/ha) and Sentop (7723 kg/ha).
- Medium producers: 4500kg/ha to 7499 kg/ha, orange: Sweet Kandy BMR (4604 kg/ha), Hygrograze BMR (5159 kg/ha),Revolusion (6236 kg/ha), Kow Kandy BMR (6470 kg/ha), Everlush (6688 kg/ha), Sugargraze (7019 kg/ha) and Kow Kandy (7359 kg/ha)
- Low producers: < 4499 kg/ha, yellow: Hygrosil BMR (3985 kg/ha) and Kow Kandy Impr. BMR (4330 kg/ha).

At the grazing stage (Dt 2), TDM production of cultivars ranged between 4124 kg/ha and 9763 kg/ha with Sentop the highest producer and Hygrosil BMR the lowest producer. Three production groups were identified:

- High producers: > 8500 kg/ha, light brown: Kow Kandy (8646 kg/ha), Revolusion (9627 kg/ha), Jumbo (9721 kg/ha), Everlush (9732 kg/ha) and Sentop (9763 kg/ha).
- Medium producers: 6000kg/ha to 8499 kg/ha, orange: Kow Kandy BMR (6713 kg/ha), Hygrograze (7008 kg/ha), Sugargraze (7045 kg/ha), Kow Kandy Impr. BMR (7255 kg/ha) and Piper (7831 kg/ha).
- Low producers: < 5999 kg/ha, yellow: Hygrosil BMR (4124 kg/ha) and Sweet Kandy BMR (5767 kg/ha).

At the silage stage (Dt 3), the TDM production of cultivars ranged between 8436 kg/ha and 15151 kg/ha with Jumbo producing higher than all the cultivars and Kow Kandy Improved BMR the lowest. The average was 11856 kg/ha, which was significantly higher than the averages of the other two cutting treatments. Four production groups were identified:

- High producers: > 15000 kg/ha, red: Jumbo (15151 kg/ha).
- Medium high producers: 13000 kg/ha to 14999 kg/ha, light brown: Kow Kandy (13471 kg/ha), Revolusion (13558 kg/ha), Sugargraze (14604 kg/ha), and Sentop (14695 kg/ha).
- Medium low producers: 10000 kg/ha to 12999 kg/ha, orange: Kow Kandy BMR (10449 kg/ha), Hygrograze BMR (10653 kg/ha), Everlush (11348 kg/ha) and Sweet Kandy BMR (11631 kg/ha)
- Low producers: < 10000 kg/ha, yellow: Kow Kandy Impr. BMR (8436 kg/ha), Piper (8966 kg/ha and Hygrosil BMR (9305 kg/ha).

A visual summarized version of results in Table 4.17 is given in Figure 4.18, to give a practical idea of the best utilization stage of each cultivar.

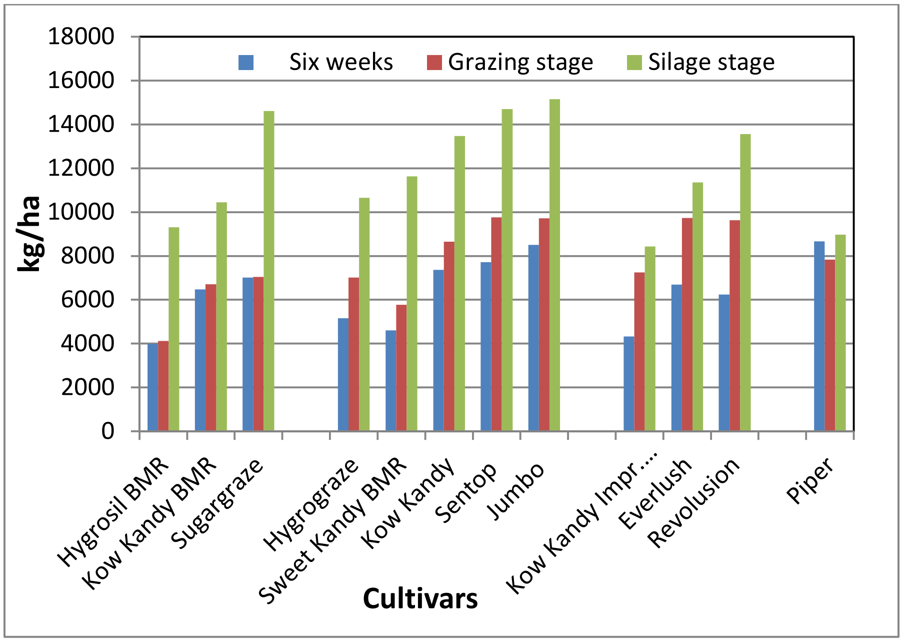

Figure 4.18: The influence of defoliation treatment on the TDM production (kg/ha) of forage sorghum cultivars planted in December

Piper was not influenced significantly by defoliation stage and can be used for all three defoliation or utilization stages. All other 11 cultivars produced the highest in the silage stage (in the case of Sugargraze, Sweet Kandy BMR, Kow Kandy, Sentop and Jumbo significantly).

The production differences between the six week defoliation and the grazing stage did not differ significantly for all 13 cultivars. From a practical management viewpoint the production of Kow Kandy improved BMR, Everlush and Revolusion was more than 1000 kg/ha higher at the grazing stage than the six weekly defoliation stage. According to this these three cultivars might be described as better grazing types.

4.2.3.5 Summary of forage sorghum results planted in December

- Six weekly cut (Dt 1)

Comparing the DM production of cultivars per cut, the following conclusion could be made:

The lowest average production was measured 8 February, six weeks after planting (Cut 1). The highest DM producers in this cut were Sentop, Jumbo and Kow Kandy BMR, although not significantly higher than the rest.

The DM production after the first six weeks regrowth (Cut 2, 22 March) was on average higher than both other cuts. The highest DM productions were measured with Jumbo and Piper, followed by Kow Kandy, Sentop, Everlush and Sugargraze.

A further six weeks of regrowth (7 May) produced, on average, 1545 kg/ha, with Piper the highest (2295 kg/ha) and the rest between 1264 kg/ha and 1865 kg/ha.

Comparing DM productions across cutting dates:
Jumbo and Sentop could be described as early to mid-season producers and Piper, Kow Kandy and Sugargraze as mid to late season producers.

In terms of total production the following five cultivars were the highest producers: Piper (8669 kg/ha), Jumbo (8508 kg/ha), Sentop (7723 kg/ha), Kow Kandy (7359 kg/ha) and Sugargraze (7019 kg/ha).The three lowest producers (< 4000 kg/ha) were Sweet Kandy BMR (4604 kg/ha), Kow Kandy Improved BMR (4330 kg/ha) and Hygrosil BMR (3985 kg/ha). The low DM production is not a disqualification, they are all three BMR (brown mid rib) cultivars that are high digestible and palatable.

- Defoliation at grazing stage (Dt 2)

In the first grazing cycle (Cut 1, 22 March) the average DM production of the cultivars was 3088 kg/ha. The highest production was measured with Sentop (4903 kg/ha) and Everlush (4574 kg/ha). The second highest group included Revolusion, Jumbo, and Kow Kandy. The lowest producers were Piper and Hygrosil BMR, with the productions less than 2000 kg/ha.

On average, the highest DM production was measured on 18 April (4681 kg/ha) which was the second grazing cycle. The highest producers were Piper, Jumbo, Revolusion, Everlush and Kow Kandy Impr. BMR with the DM production of more than 5000 kg/ha. The lowest producer was Hygrosil BMR (2670 kg/ha).

- Silage (Dt 3)

DM production of the cultivars defoliated at the silage stage (Dt 3) ranged between 8436 kg/ha and 15151 kg/ha. The high producers (top five in ranking) were Jumbo, Sentop, Sugargraze, Revolusion and Kow Kandy with the DM production ranged between 13471 kg/ha and 15151 kg/ha. The medium producers were Sweet Kandy BMR, Everlush, Hygrograze BMR, Kow Kandy BMR and the low producers were Hygrosil BMR, Piper and Kow Kandy Improved BMR.

4.2.4 Results of the January planting date

As indicated in paragraph 3.2.4 (Chapter 3), the 12 forage sorghum cultivars were subjected to three defoliation treatments: (i) six weekly (Dt 1), (ii) cut repeatedly when it reached a grazing stage (Dt 2) that was taken as (± 800 mm high) and (iii) at a silage stage (Dt 3). The results of the three defoliation treatments were analysed separately.

4.2.4.1 The DM production of forage sorghum cultivars defoliated every six weeks (Dt 1)

In the treatments that were planted in January and defoliated every six weeks (Dt 1), only two cuts were achieved for the season. According to the statistical analyses in Addendum B5, a significant difference in DM production was observed for cultivars ($P \leq 0.05$) and cuts ($P \leq 0.001$), as the main treatments. The interaction between cuts and cultivars was non-significant ($P \leq 0.099$). However a significant trend was observed when the results were compared with LSD of 589. The differences between cultivars, for each cut separately, are shown in different colours in Table 4.18 (Light brown = high producers, orange = medium producers, yellow = low producers). Difference between the two cuts, for each cultivars, are shown with the symbols <,> and =).

On the 6th March (Cut 1) Jumbo produced 936 kg/ha and Sentop 911 kg/ha (light brown) and that was significantly higher than the 283 kg/ha of Kow Kandy Improved BMR and the 309 kg/ha of Sweet Kandy BMR (yellow). The medium production group (orange) included Kow Kandy, Hygrograze, Kow Kandy BMR, Sugargraze, Piper, Revolusion, Everlush and Hygrosil BMR, which produced between 352 kg/ha and 787 kg/ha

Table 4.18: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated every six weeks

Forage sorghum Cultivars	Cut 1 06 March	Cut 2 14 April
Everlush	352 ab <	1126 abc
Revolusion	460 ab <	1340 ab
Kow Kandy BMR	554 ab <	1269 ab
Hygrosil BMR	352 ab =	642 c
Hygrograze	595 ab =	887 bc
Sentop	911 a =	1473 ab
Kow Kandy Impr. BMR	283 b =	642 c
Piper	482 ab <	1627 ab
Jumbo	936 a <	1664 a
Sweet Kandy BMR	309 b =	577 c
Kow Kandy	787 ab <	1704 a
Sugargraze	528 ab <	1337 ab
Mean	546 ^{b}	1191^{a}

LSD (P≤ 0.99) Interaction; Cv X Cut:589
Cut: 127
Coefficient of variation = 35.4%
<> shows significant difference between cuts (LSD = 589)
= shows no significant difference
Values with the same Roman letter do not differ significantly

On the 14th April (Cut 2) Jumbo produced 1664 kg/ha and Kow Kandy 1704 kg/ha (light brown) and that was significantly higher than the 642 kg/ha for both Kow Kandy Improved BMR and Hygrosil BMR and the 577 kg/ha Sweet Kandy BMR (yellow). The medium production group (orange) included Sentop, Hygrograze, Kow Kandy BMR, Sugargraze, Piper, Revolusion and Everlush which produced between 887kg/ha and 1627kg/ha

The average DM production in Cut 2 (14 April) was significantly higher than that in Cut 1 (06 March) (1191 kg/ha vs 546 kg/ha). Seven cultivars (Everlush, Revolusion, Kow Kandy BMR, Piper, Jumbo, Kow Kandy and Sugargraze) followed the same trend (lower in Cut 1 than in Cut 2). There was no significant difference between DM productions of the two cuts for the rest of the cultivars.

According to Table 4.13, the rainfall between planting (January) and Cut1 (March) was approximately 108.3 mm and between the two cuts approximately 48 mm. It seems as if the rainfall in the two mentioned periods did not influence DM production, but that it was rather influenced by total rainfall for the full season.

A visual summarized version of results in Table 4.18 is given in Figure 4.19, to give a practical idea of the best utilization stage of each cultivar.

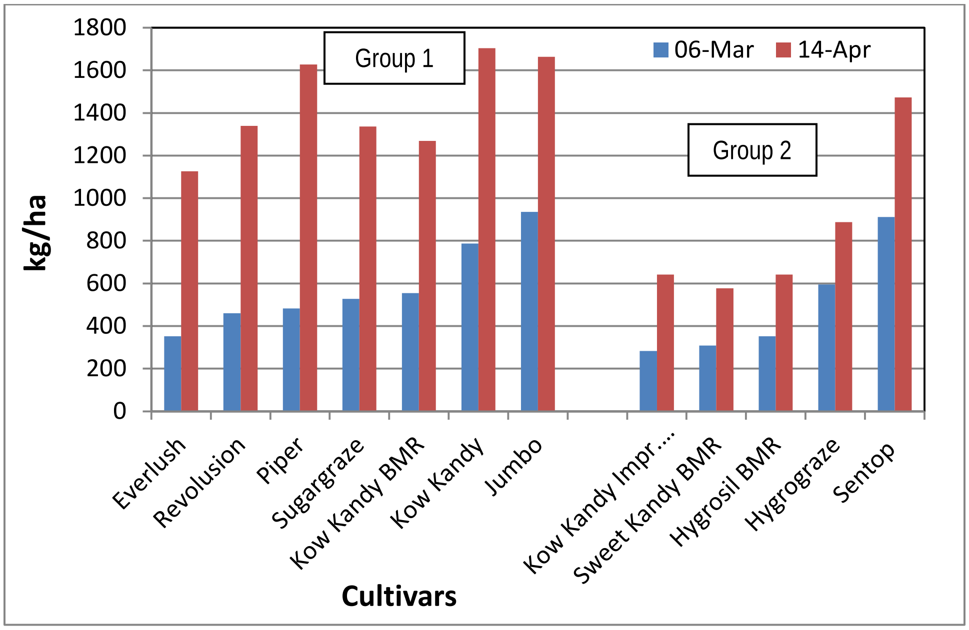

Figure 4.19: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated every six weeks

All 12 cultivars produced higher on 14thApril (Cut 2) than on 6thMarch. In Group 1 the differences were significant and in Group 2 non-significant. Kow Kandy, Jumbo and Sentop were the highest producers on 6th March, while Piper, Kow Kandy and Jumbo were the highest producers on 14Th April.

On 14th April, the average production (all cultivars) was 1191kg/ha that was significantly higher (LSD = 127) than the 546 kg/ha of Cut 1 (6th March).

4.2.4.2 The DM production of forage sorghum cultivars defoliated at the grazing stage (Dt 2)

An average height of ± 800 mm was taken as the most ideal grazing stage for cattle and plants were cut at that height (see Par. 4.2.4.3). For the January, planting only one cut could be done, on the 3rd April. According to the statistical analyses in Addendum B6, a significant difference ($P \leq 0.05$) was observed for cultivars as the main treatment. The results are shown in Table 4.19.

Table 4.19: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated at a grazing stage

Forage sorghum Cultivars	Cut 1 03 April
Sentop	5876 a
Jumbo	4713 ab
Sugargraze	3721 abc
Revolusion	3319 bc
Kow Kandy	2781 bcd
Piper	2744 bcd
Hygrograze	2585 bcd
Kow Kandy BMR	2510 cd
Kow Kandy Impr. BMR	2500 cd
Everlush	2312 cd
Sweet Kandy BMR	1574 cd
Hygrosil BMR	1488 d
Mean	3010
LSD (P≤ 0.01); Interaction: 2165 Coefficient of variation = 50% Values with the same Roman letter do not differ significantly	

The significant differences in DM production, between cultivars are indicated with different Roman letters. Four production groups could be classified and marked in different colours in the table: Red = > 5500, light brown = 2550 kg/ha to 5500 kg/ha, orange = 1500 kg/ha to 2550 kg/ha and yellow = <1500 kg/ha.)

- High producers: Sentop with 5876 kg/ha (red).
- Medium high producers: Jumbo (4713 kg/ha), Sugargraze (3721 kg/ha), Revolusion (3319 kg/ha), Kow Kandy (2781kg/ha), Piper (2744 kg/ha) and Hygrograze (2585 kg/ha) (light brown).
- Medium low producers: Kow Kandy BMR, Kow Kandy Impr. BMR, Everlush and Sweet Kandy BMR (1574 kg/ha and 2510 kg/ha) (orange), which produced non-significantly lower than Kow Kandy, Piper and Hygrograze.
- Lowest producers: Hygrosil BMR (1488 kg/ha) (yellow).They were non-significantly lower than the two afore mentioned groups.

4.2.4.3 The DM production of forage sorghum cultivars defoliated at the silage stage (Dt 3)

For the January planting, only one cut could be done at a silage stage, on the 5th May. According to the statistical analyses in Addendum B7, there was a significant difference between the cultivars ($P \leq 0.05$). The significant differences in DM production, between cultivars are indicated with different Roman letters in the Table 4.20.

Table 4.20: DM production (kg/ha) of forage sorghum cultivars planted in January and defoliated at a silage stage

Forage sorghum Cultivars	Cut 1 05 May
Sentop	10567 a
Jumbo	7180 b
Kow Kandy	6170 bc
Everlush	5602 bcde
Sugargraze	5476 bcde
Kow Kandy Impr. BMR	5323 bcde
Revolusion	4597 cde
Kow Kandy BMR	4196 cde
Sweet Kandy BMR	4196 cde
Hygrograze	4088 de
Piper	3847 de
Hygrosil BMR	2957 e
Mean	5350
LSD (P≤0.008); Interaction: 2264 Coefficient of variation = 29.42% Values with the same Roman letter do not differ significantly	

The DM production of the cultivars ranged between 2957 kg/ha and 10567 kg/ha, with Sentop being the highest and Hygrosil BMR the lowest producer. Four production groups could be classified and marked in different colours in the table: Red = high production group, brown = medium high production group, orange = medium low production group and yellow = lowest production group.

- High producer: Sentop with 10567 kg/ha (red).
- Medium high producer: Jumbo with 7180 kg/ha (light brown).
- Medium low producers: (5323 kg/ha to 6170 kg/ha) included Kow Kandy, Everlush, Sugargraze and Kow Kandy Impr. BMR (orange).
- Low producers: Revolusion, Kow Kandy BMR, Sweet Kandy BMR, Hygrograze, Piper and Hygrosil BMR with the productions ranging between 2957 kg/ha and 4597 kg/ha (yellow).

4.2.4.4 Total Dry Matter (TDM) production for the January planting date

The experimental plots that were planted in January were subjected to three defoliation treatments. The total dry matter production of cultivars at the different defoliation treatments are shown in Table 4.20 and Figure 4.20.

According to the statistical analyses in Addendum B88, a significant difference (P≤0.001) in DM production was observed as influenced by cutting treatment as the main treatment. The influence of interaction between cutting treatment and cultivars on DM was non-significant (P≤0.240).

Table 4.20: The TDM production (kg/ha) of forage sorghum cultivars planted in January on NGT

Forage sorghum Cultivars	Six weeks	Grazing stage	Silage stage
Everlush	1478 a =	2312 c<	5602bc
Revolusion	1800 a =	3319bc =	4597cd
Kow Kandy BMR	1824 a =	2510 bc =	4196cd
Hygrosil BMR	994 a =	1488 c =	2958 d
Hygrograze	1482 a =	2585bc =	4088cd
Sentop	2384 a <	5876 a<	10567a
Kow Kandy Impr. BMR	925 a =	2500bc<	5323bc
Piper	2109 a =	2744bc =	3847 d
Jumbo	2600 a =	4713 ab<	7180b
Sweet Kandy BMR	886 a =	1574c<	4193cd
Kow Kandy	2491 a =	2781bc<	6170bc
Sugargraze	1865 a =	3721 abc =	5476bc
Mean	1737 ^{c}	3010 ^{b}	5350 ^{a}
LSD (P≤0.05) Interaction; Cv X Cut: 2287.0 Cut: 660.2 Coefficient of variation = 48.5% <> shows significant difference between cuts (LSD = 2287.0) = shows no significant difference Values with the same Roman letter do not differ significantly			

When comparing the results with a LSD of 4183.5 (within each cutting treatment), there was a trend of significance in the TDM production (only at the grazing and silage stages).The colour codes are used to compare cultivars per cutting treatment in Table 4.20. Differences of individual cultivars between cuts are indicated with symbols <, = and >.

At the six weekly defoliation treatment (Dt 1), the TDM production of the cultivars ranged between 886 kg/ha and 2600 kg/ha, with Jumbo being the highest and Sweet Kandy BMR the lowest producer. For management purposed (not significantly) three production groups were identified subjectively:

- High producers: > 2500 kg/ha, Jumbo (2600 kg/ha).
- Medium producers: 1500 kg/ha to 2499 kg/ha: Kow Kandy, Sentop, Piper, Sugargraze, Kow Kandy BMR and Revolusion with TDM productions ranging between 1800 kg/ha and 2499 kg/ha.
- Low producers: < 1500 kg/ha: Hygrograze BMR, Everlush, Hygrosil BMR, Kow Kandy Impr. BMR and Sweet Kandy BMR with TDM productions ranging between 886 kg/ha and 1482 kg/ha.

At the grazing stage (Dt 2), the TDM production of cultivars ranged between 1488 kg/ha and 5876 kg/ha. The highest producer was Sentop (5876 kg/ha) and Hygrosil BMR (1488 kg/ha) the lowest producer. Three production groups were identified when defoliated at a typical grazing stage (LSD = 2287):

- High producers: > 5000 kg/ha, light brown: Sentop (5876 kg/ha).
- Medium producers: 2500 kg/ha to 4999 kg/ha, orange: Jumbo, Sugargraze, Revolusion, Kow Kandy, Piper, Hygrograze, Kow Kandy BMR and Kow Kandy Impr. BMR with TDM productions ranging between 2500 kg/ha and 4713 kg/ha.
- Low producers: < 2500 kg/ha, yellow: Everlush, Sweet Kandy BMR and Hygrosil BMR with TDM productions ranging between 1488 kg/ha and 2312 kg/ha.

At the silage stage (Dt 3), the TDM production of cultivars ranged between 2958 kg/ha and 10567 kg/ha. Sentop produced significantly higher than all the cultivars.
Four production groups were identified when defoliated at silage stage (LSD = 2287):

- High producers: > 10000 kg/ha, red: Sentop (10567 kg/ha).
- Medium high producers: 5000 kg/ha to 9999 kg/ha, light brown: Jumbo, Kow Kandy, Everlush, Kow Kandy BMR Impr and Sugargraze with TDM productions ranging between 5323 kg/ha and 7180 kg/ha.).
- Medium low producers: 3000kg/ha to 4999 kg/ha, orange: Revolusion, Kow Kandy BMR, Sweet Kandy BMR, Hygrograze BMR and Piper with TDM productions ranging between 3847 kg/ha and 4597 kg/ha).

- Low producers: < 3000 kg/ha, yellow: Hygrosil BMR (2958 kg/ha).

When comparing the results, as influenced by cutting treatment with a LSD of 660.2, the average TDM production was 5350 kg/ha at the silage stage, 3010 kg/ha at the grazing stage and 1737 kg/ha at the six weeks stage. These values differed significantly from each other.

A visual summarized version of results in Table 4.20 is given in Figure 4.20, to give a practical idea of the best utilization stage of each cultivar.

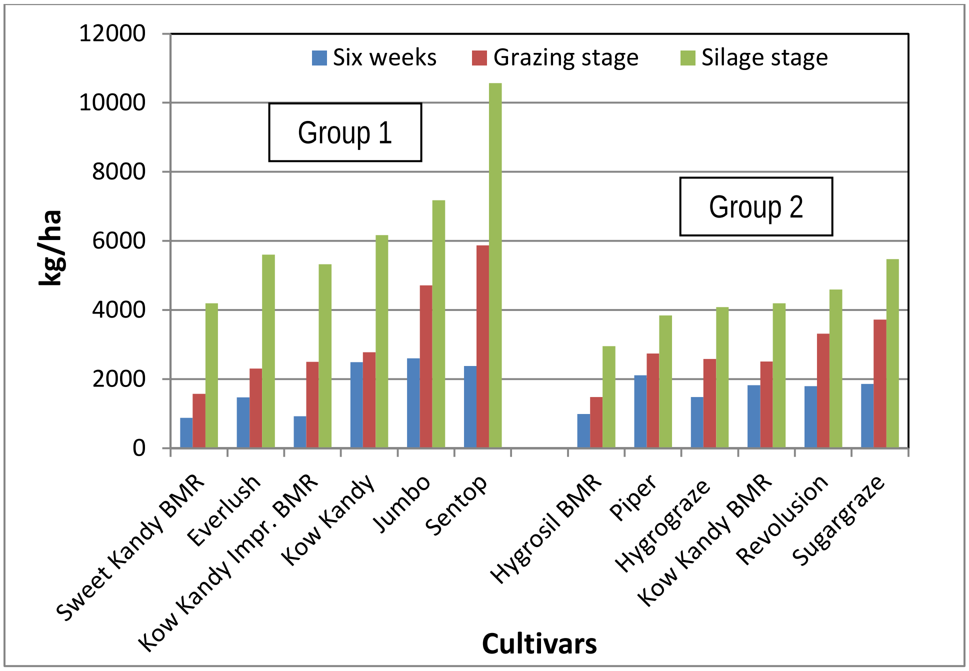

Figure 4.20: The influence of defoliation treatment on the TDM production (kg/ha) of forage sorghum cultivars planted in January

The DM production in the silage stage of the six cultivars in Group 1 was significantly higher than that of the other two treatments. The production at the grazing stage of Jumbo and Sentop was at least 1000 kg/ha higher than at the six weeks defoliation stage (in the case of Sentop the difference was significant). Kow Kandy was the third highest silage producer. The six cultivars in Group 2 were the lowest producers, except Piper with relative high production at the six weeks and grazing stages and Sugargraze with the third highest production, of all cultivars, in the grazing sage.

4.2.4.5 Summary of the forage sorghum results when planted in January

- Six weekly cut (Dt 1)

Comparing the DM production of cultivars per cut the following conclusion could be made.

On average, the lowest production (546 kg/ha) was measured on 6th March, six weeks after planting. The highest DM producers were Sentop and Jumbo although not significantly higher than the rest.

The average six weeks regrowth (1191 kg/ha) (Cut 2, 14 April) was higher than in Cut 1. The highest DM productions were measured for Kow Kandy and Jumbo. The second highest group included Piper, Sentop, Revolusion, Sugargraze, Kow Kandy BMR, Everlush and Hygrograze, followed by the rest (below 650 kg/ha).

In terms of total production, the following five cultivars were the highest producers: Jumbo, Kow Kandy, Sentop, Piper and Sugargraze. The three lowest producers (<1000 kg/ha) were: Hygrosil, Kow Kandy Impr. BMR and Sweet Kandy BMR.

- Defoliation at grazing stage (Dt 2)

The DM production of all cultivars ranged between 1488 kg/ha and 5876 kg/ha with Sentop the highest cultivar and Hygrosil BMR the lowest producer. The highest producers (top five in ranking) were Sentop, Jumbo, Sugargraze, Revolusion and Kow Kandy while the lowest producers were Everlush, Sweet Kandy BMR and Hygrosil BMR.

- Defoliation at silage stage (Dt 3)

The DM productions of the cultivars defoliated at the silage stage (Dt 3) ranged between 2957 kg/ha and 10567 kg/ha, with Sentop the highest and Hygrosil BMR the lowest producer. The high producers (top five in ranking) were Sentop, Jumbo, Kow Kandy, Everlush and Sugargraze (between 5476 kg/ha and 10567 kg/ha). The low producers were Hygrograze BMR, Piper and Hygrosil BMR with DM productions ranging between 2957 kg/ha and 4088 kg/ha.

4.2.5 Nutritional value

Fodder quantity alone is not adequate for measuring the feeding values of the pastures. According to Fick and Mueller (1989) the crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) are parameters for considering fodder quality. The CP, ADF and NDF content of the forage sorghum cultivars planted at Nooitgedacht in December and January and harvested at the grazing and silage stages, were analysed and are shown in Table 4.21.The chemical analysis was done by the accredited feed laboratory at Cedara, Department of Agriculture and Environment, KZN.

Table 4.21: Nutritional value of forage sorghum cultivars planted in December and January and defoliated at a grazing and a silage stage

Utilization stage	Cultivars	CP (%)		ADF (%)		NDF (%)	
		Dec	Jan	Dec	Jan	Dec	Jan
Grazing	Everlush	11.33	20.87	38.52	44.93	55.13	50.82
	Revolusion	14.06	19.92	45.69	45.98	54.80	49.52
	Kow Kandy BMR	15.62	18.75	44.12	41.22	52.56	47.91
	Hygrosil BMR	14.84	17.80	43.94	45.10	52.27	51.32
	Hygrograze	14.84	19.92	42.93	41.27	50.01	48.71
	Sentop	12.11	18.36	47.49	46.19	56.04	53.18
	Kow Kandy Impr. BMR	11.72	17.58	44.35	42.34	64.22	48.67
	Piper	11.33	17.19	50.91	45.11	59.11	51.72
	Jumbo	11.33	16.80	51.41	46.44	58.71	51.73
	Sweet Kandy BMR	12.69	17.58	45.68	43.18	51.47	50.83
	Kow Kandy	14.45	17.58	47.47	44.70	53.25	50.46
	Sugargraze	19.53	19.53	44.64	45.91	50.95	50.33
Silage	Everlush	9.37	12.89	46.47	45.10	58.22	57.44
	Revolusion	6.44	7.81	45.95	50.80	56.07	60.55
	Kow Kandy BMR	8.20	10.55	43.01	43.63	55.67	58.33
	Hygrosil BMR	8.98	10.94	43.74	43.67	55.76	57.41
	Hygrograze	10.16	11.52	43.41	40.29	55.39	56.72
	Sentop	8.59	6.44	45.00	50.11	54.22	59.16
	Kow Kandy Impr. BMR	8.40	7.81	48.65	44.01	58.42	58.19
	Piper	8.59	8.79	53.91	53.51	63.67	66.75
	Jumbo	5.86	6.84	49.09	49.31	58.05	54.00
	Sweet Kandy BMR	9.37	12.11	43.97	37.23	55.44	58.22
	Kow Kandy	8.20	8.98	45.72	46.30	55.58	60.47
	Sugargraze	7.81	10.16	43.11	41.87	54.59	55.56

CP = crude protein, ADF = acid detergent fibre, NDF = neutral detergent fibre

The norms used for evaluation of the CP content are as follows:

Minson and Rutherford (1962) stated that if CP content is between 8% and 12% animals will maintain weight. According to Minson and Milford (1967), if the CP content falls below 6% to 8% appetite will be depressed. With a CP content above 13% the animals will maintain their weight and above 18% the animals will gain weight. Cultivars were classified into the following groups: High CP content group = 18% and more (red), medium CP content group = 8% to 18% (light brown), low CP content = < 8% (yellow).

4.2.5.1 Crude protein (CP) at grazing and silage stage

According to Table 4.30 the CP content of cultivars harvested at the grazing stage ranged between 11.33% and 19.53% for December planting date and between 17.19% and 20.87 % for January planting date. That means that the CP was of such a standard that animals will at least maintain weight.

At silage stage, the CP ranged between 5.86% and 10.16% when planted in December and for the January planting date between 6.44% and 12.89%.

At grazing stage, two groups were identified, according to the mentioned norms:

- Cultivars with a high CP content, (above 18%, red in the table): For the December planting date Sugargraze had a CP content of 19.53%. Everlush, Revolusion, Kow Kandy BMR, Hygrograze, Sentop and Sugargraze had a CP content of between 18.36% and 20.87% when planted in January.

- Cultivars with medium CP content; (CP content of between 8% and 18%, light brown in table): Cultivars in this group include Kow Kandy BMR, Hygrosil BMR, Hygrograze, Kow Kandy, Revolusion, Sweet Kandy BMR, Sentop, Kow Kandy Improved BMR, Everlush, Piper and Jumbo with a CP content of 11.33% and 15.62% respectively, when planted in December. For the January planting date cultivars in the medium group are Kow Kandy Improved BMR, Sweet Kandy BMR, Kow Kandy, Piper, Hygrosil BMR and Jumbo with the CP contents ranging between 16.8% and 17.58%.

At silage stage, two groups were identified, according to the mentioned norms:

- Cultivars with a medium CP content: (between 8 and 18%, light brown): Everlush, Kow Kandy BMR, Hygrosil BMR, Hygrograze, Piper, Sweet Kandy BMR and Kow Kandy with a CP content ranging between 8.2 and 10.2% when planted in December. For the January planting date cultivars in this group are Everlush, Kow Kandy BMR, Hygrosil BMR, Hygrograze, Piper, Sweet Kandy BMR, Kow Kandy and Sugargraze with the CP content ranging between 8.79% and 12.89%.

- Cultivars with a low CP content; (< 8%, yellow): Revolusion, Jumbo and Sugargraze with CP contents ranging between 5.86% and 7.81% when planted in December. For the January planting date cultivars in this group are Revolusion, Sentop and Kow Kandy Impr. BMR and Jumbo with CP contents ranging between 6.44% and 7.81%.

When comparing the effect of planting date on the CP content of the cultivars harvested at grazing and silage stage, all the forage sorghum cultivars planted in January showed higher CP contents than those planted in December, except for Sentop and Kow Kandy Impr. BMR at the silage stage.

When comparing the effect of cutting stage on the CP content of the cultivars planted in December and January, the CP content of all the cultivars harvested at grazing stage were higher than those harvested at the silage stage.

4.2.5.2 Acid Detergent Fibre (ADF) at grazing and silage stage

According to Blezinger (1999), an ADF content of below 31% is considered as prime quality, 31% to 35%as very good quality, 36% to 40% good quality, 41% to 42% medium quality, 43% to 45% low quality and above 45% very low quality. The forage sorghum cultivars were classified according to the above mentioned norms.

According to Table 4.30 the ADF content at grazing stage for cultivars that were planted in December ranged between 38.52% and 51.41% and for the January planting date between 41.22% and 46.44%.

At the silage stage the ADF content of cultivars planted in December varied between 43.01% and 53.91% for Piper and for the January planting date between 40.29% and 53.51%.

At grazing stage, two groups were identified, according to the mentioned norms:

- Good quality, 36% to 40% (red): Everlush, 38.52% when planted in December.
- Medium quality, 41% to 42% (light brown): Kow Kandy Improved BMR and Hygrograze with an ADF content of 41.22% and 41.27%, respectively when planted in January.
- Low quality, 43% to 45% (orange): Kow Kandy BMR, Hygrosil BMR, Hygrograze, Kow Kandy Improved BMR and Sugargraze with ADF contents ranging between 42.93% and 44.35% for the December planting date. For the January planting date, the ADF contents ranged between 42.34% and 44.93% for Everlush, Kow Kandy Impr. BMR, Sweet Kandy BMR and Kow Kandy.
- Very low quality, lower than 45% (yellow): Revolusion, Sentop, Piper, Jumbo, Sweet Kandy BMR and Kow Kandy with ADF contents ranging between 45.68% and 51.41% for the December planting date. For the January planting date this group Included Hygrosil BMR and Sugargraze with ADF contents of 45.11% and 46.44% respectively.

At silage stage, four groups were identified, according to the mentioned norms:

- Good quality, 36% to 40% (red): Hygrograze and Sweet Kandy BMR with the ADF contents of 37.23% and 40.29%, respectively when planted in January.
- Medium quality, 41% to 42% (light brown): Sugargraze, 41.87% when planted in January.
- Low quality, 43% to 45% (orange): Kow Kandy Impr. BMR, Hygrosil BMR, Hygrograze, Sentop, Sweet Kandy BMR and Sugargraze with ADF contents ranging between 43.01% and 45.00% for the December planting date. Included in this group was Kow Kandy Improved BMR for the January planting date.
- Very low quality, lower than 45% (yellow): Everlush, Revolusion, Kow Kandy Impr. BMR, Piper, Jumbo and Kow Kandy with ADF contents ranging between 45.72% and 53.91% for the December planting date. Included in this group was Sentop for the January planting date.

4.2.5.3 Neutral Detergent Fibre (NDF)

According to Blezinger (1999), the NDF content is considered as prime quality if it is below 40, 40% to 46% very good quality, 47% to 53% good quality, 54% to 60% medium quality, 61% to 65% low quality and above 65% very low quality. Forage sorghum cultivars were grouped based on the above mentioned norms.

According to Table 4.30 the NDF content at the grazing stage for cultivars planted in December ranged between 50.01% and 64.22% and for the January planting date, between 47.91% and 53.18%. At the silage stage the NDF content of cultivars planted in December varied between 54.22% and 63.67% and for the cultivars planted in January the ADF values ranged between 54.00% and 66.75%.

At grazing stage, three groups were identified, according to the mentioned norms:

- Good quality, 47% to 53% (red): Kow Kandy BMR, Hygrosil BMR, Hygrograze, Sweet Kandy BMR, Kow Kandy and Sugargraze and with the NDF content ranging between 50.01% and 53.25% when planted in December. All the cultivars had the NDF ranging between 47.91% and 53.18% when planted in January.
- Medium quality, 54% to 60% (light brown): Everlush, Revolusion, Sentop, Piper and Jumbo and with the NDF content ranging between 54.80% and 59.11%when planted in December.
- Low quality, 61% to 65% (orange): Kow Kandy Impr. BMR with the NDF of 64.22%.

At the silage stage the NDF content of cultivars planted in December were between 54.22% and 63.67% and for the cultivars planted in January the ADF values ranged between 54.00% and 66.75%. In both the planting dates, all the cultivars were of medium quality, (54% to 60%, light brown) except for Piper with the NDF of 63.67% (low quality) for December planting and 66.75% (very low quality) for the January planting date.

4.2.5.4 Summary of nutritional value

The nutritional value was on average higher in the grazing stage than in the silage stage, which is expected from younger material.

The lowest CP % (< 8%) was measured in the December planting date, with the cultivars Sentop, Jumbo and Revolution, in the silage stage. The CP % for the rest of the cultivars ranged between 8% and 10% (silage stage), while highest (> 10%) was measured with Everlush, Kow Kandy BMR, Hygrosil BMR, Hygrograze, Sweet Kandy BMR and Sugargraze.

In the grazing stage the CP % ranged between 11% and 20.87%, with the highest values measured with Everlush, Sugargraze, Revolution, Hygrograze and Kow Kandy BMR (> 18.75%).

The ADF content of material in the silage stage ranged between 37.2 % and 53.9 %, with Piper and Revolution the highest (> 50%) and with Hygrograze and Sweet Kandy BMR the lowest (< 41%). In the grazing stage the ADF content ranged between 38.5% and 51.4%, with Piper and Jumbo the highest (> 50 %) and Everlush, Kow Kandy BMR and Hygrograze the lowest (< 42%).

The NDF content of material in the silage stage ranged between 54.0% and 66.7%, with Revolusion, Piper and Kow Kandy the highest (> 60 %) and with Jumbo and Sugargraze the lowest (< 54%).In the grazing stage the NDF content ranged between 48.7% and 59.1%, with Kow Kandy Improved BMR the highest (> 60 %) and Revolution, Kow Kandy BMR, Hygrograze and Kow Kandy Improved BMR the lowest (< 42%). Kow Kandy Improved BMR showed the lowest NDF content in the January planting date and the highest in the December planting date.

If the average CP, ADF and NDF contents of the two planting dates (grazing stage) are considered Kow Kandy BMR and Hygrograze were the cultivars with the highest nutritional value, followed by Everlush, Revolution, Kow Kandy and Sugargraze. In the silage stage Hygrograze, Sweet Kandy BMR and Sugargraze could be classified as the cultivars with the highest nutritional value.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

There is an increasing demand of fodder due to poor veld conditions and less available grazing areas which cannot meet the nutritional requirements for optimum animal production. New initiatives to address this demand have to be derived to ensure adequate fodder flow in terms of quality and quantity of fodder especially during the dry periods. Forage sorghum can be a solution by which the productivity and stability of animal production can be raised above natural level by ensuring the availability of good quality feed throughout the year (Dannhauser 1991).

Engelbrecht and Kirkman (2004) stated that the establishment of annual pastures such as forage sorghum requires careful thought and planning because of the high financial output. Different cultivars are available on the market and the lack of research based knowledge of agricultural practices such as correct planting date, utilisation stages, nutritive value and yield of these cultivars are not known. There was thus an urgent need to evaluate the effect of planting dates and defoliation stages on the dry matter production of forage sorghum cultivars.

Thirteen forage sorghum cultivars were planted in the Gauteng at Dewageningsdrift (DWD) and In Mpumalanga at Nooitgedacht (NGT) in December, January and February. They were defoliated six weekly, at a grazing stage and a silage stage to determine DM production and nutritive value. The following conclusions were made with respect to each parameter:

From the cultivars used in these experiments, the following are freely available in the market: Kow Kandy, Jumbo, Sugargraze, Piper, Sentop and Hygrograze

5.1.1 The effect of planting date and defoliation on the total dry matter (TDM) production of forage sorghum cultivars.

The TDM production decreased progressively with planting date at both sites. At NGT planting was done in all three months, but because poor germination and growth, most probably because of the low temperatures and rainfall in autumn, no results were available.

- Dewageningsdrift

At DWD the TDM production of cultivars planted in <u>December</u>, was on average 10.8 t/ha when defoliated six weekly, 8.5 t/ha when defoliated at the grazing stage and 17.9 t/ha at the silage stage. The highest producer was Jumbo in all three cutting treatments.

When defoliated six weekly the following cultivars produced higher than 10.0 t/ha: Sentop, Kow Kandy BMR, Piper, Kow Kandy Improved BMR, Revolusion, Everlush and Kow Kandy. All cultivars defoliated six weekly, produced on average low at Cut 1 (Jan), the highest at Cut 2 (March), lower in April (Cut 3) and the lowest in June (Cut 4). The results obtained during the four cuttings were used to categorize the mentioned cultivars in three groups:

Group 1 (Late season producers): Everlush, Kow Kandy BMR, Piper, Silo and Sugargraze

Group 2 (Mid-season producers): Jumbo, Kow Kandy Improved BMR and Kow Kandy

Group 3 (Early season producers): Sentop.

When defoliated at the grazing stage the following cultivars produced more than 10.0 t/ha: Kow Kandy, Kow Kandy BMR, Revolusion and Piper with the DM productions ranging between 10455 kg/ha and 12478 kg/ha.

The average TDM production in the silage stage was only 16 % lower in the January planting, but 86 % lower in the February planting. The best silage producers planted in December were Jumbo, Sugargraze, Kow Kandy Improved BMR and Kow Kandy.

The TDM of cultivars planted in <u>January</u>, was on average 5.2 t/ha when defoliated six weekly, 4.9 t/ha when defoliated at the grazing stage and 15.0 t/ha at the silage stage.

When defoliated six weekly the following cultivars produced higher than 5.0 t/ha: Sugargraze, Revolusion, Kow Kandy, Sentop, Everlush and Kow Kandy BMR.

When defoliated at the grazing stage the following cultivars produced more than 5.0 t/ha: Hygrosil BMR, Sweet Kandy BMR, Revolusion and Hygrograze.

At the silage stage Jumbo, Sugargraze, Sentop, Hygrograze, Kow Kandy and Revolusion produced higher than 15 t/ha.

The TDM of cultivars planted in <u>February</u>, was on average 1.9 t/ha when defoliated six weekly, 2.7 t/ha when defoliated at the grazing stage and 2.5 t/ha at the silage stage.

When defoliated six weekly the following cultivars produced higher than 1.5 t/ha: Piper, Sentop Kow Kandy, Hygrograze BMR, Kow Kandy BMR, Hygrosil BMR, Jumbo, Kow Kandy Improved BMR, Everlush and Silo 700,

When defoliated at the grazing stage the following cultivars produced more than 2.8 t/ha: Everlush, Kow Kandy Improved BMR, Hygrosil BMR, Sweet Kandy BMR and Sugargraze.

At the silage stage Sentop, Kow Kandy BMR, Kow Kandy and Kow Kandy Improved BMR produced higher than 3 t/ha.

- Nooitgedacht

At NGT the TDM of cultivars planted in December, was on average 6.4 t/ha when defoliated six weekly, 7.8 t/ha when defoliated at the grazing stage and 11.9 t/ha at the silage stage.

When defoliated six weekly the following cultivars produced higher than 7.5 t/ha: Piper, Jumbo and Sentop with the DM production ranging between 8508 kg/ha and 7723 kg/ha.

When defoliated at the grazing stage the following cultivars produced more than 8.5 t/ha: Sentop, Everlush, Jumbo, Revolusion and Kow Kandy with the DM production ranging between 9763 kg/ha and 8646 kg/ha.

At the silage stage Jumbo, Sentop and Sugargraze produced higher than 14.5 t/ha.

The TDM of cultivars planted in January, was on average 1.7 t/ha when defoliated six weekly, 3.0 t/ha when defoliated at the grazing stage and 5.3 t/ha at the silage stage.

When defoliated six weekly the following cultivars produced higher than 2.4 t/ha: Jumbo (2600 kg/ha) and Kow Kandy (2491 Kg/ha).

When defoliated at the grazing stage the following cultivars produced more than 4.5 t/ha: Sentop (5876 kg/ha) and Jumbo (4713 kg/ha).

At the silage stage Sentop produced the highest with 10567 kg/ha and Jumbo with 7180 kg/ha.

Because of low germination and production the February planted results are not given

5.2 RECOMMENDATIONS ACCORDING TO RESULTS FROM THE STUDY

All the cultivars used in the study are not current freely available in the market and for this reason the following recommendations include only the available cultivars.

On Dewageningsdrift the TDM at the six week cutting treatment was 53 % lower when planted in January, compared to the December planting date, and 82 % lower when planted in February.

The best producers (freely available) for the December planting date in Gauteng are Jumbo, Sentop, Piper and Kow Kandy, to be defoliated six weekly.

Jumbo, Kow Kandy and Piper can be used for less frequent defoliation, at the grazing stage and a height of ± 800 mm.

The best silage producers planted in December were Jumbo, Sugargraze, and Kow Kandy.

The following, freely available cultivars can to be planted in **January**, to be defoliated six weekly: Silo 700, Kow Kandy, Hygrograze, Jumbo, Sentop and Sugargraze.

Jumbo, Sugargraze, Sentop, Hygrograze and Kow Kandy produced the most silage when planted in January.

Two cultivars to be mentioned in terms of their high sugar content and palatability are Sweet Kandy BMR and Sugargraze. They can be used for foggage and silage.

When there is an urgent need for fodder during late autumn, Sweet Kandy BMR and Sugargraze can be planted and defoliated at the grazing stage.

On Nooitgedacht the TDM at the six week cutting treatment was 73 % lower than when planted in January, compared to the December planting date. At the grazing stage it was 61 % lower and at the silage stage 55 % lower. That is an indication that the forage sorghums should be defoliated less frequently on the Mpumalanga highveld and that will be at the grazing stage (height ± 800 mm).

The freely available cultivars that produced the best when defoliated six-weekly and planted in **December**, on the **Mpumalanga highveld**, were Sentop, Jumbo and Kow Kandy.

If necessary to plant in January the following freely available cultivars did the best in the experiment: Sentop, Jumbo, Sugargraze, Kow Kandy and Piper.

For silage production on the Mpumalanga highveld the following cultivars should be planted in December: Jumbo, Sentop, Sugargraze and Kow Kandy

According to the results, planting in February is not advisable in both provinces.
Some cultivars showed regrowth after cutting the silage. The quantities of regrowth were indicated in the appropriate tables and can be used as late grazing.

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ADDENDUM A1

======= SORGHUM TRIAL: DECEMBER PLANTING (DWD): TOTAL DM PRODUCTION =======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	1	11.373	11.373	1.90	
REP.WPLOT stratum					
CULTIVAR	12	678.100	56.508	9.42	<.001
Residual	12	72.013	6.001	1.51	
REP.WPLOT.SPLOT stratum					
CUT_TMT	2	1272.313	636.157	160.29	<.001
CULTIVAR.CUT_TMT	24	421.751	17.573	4.43	<.001
Residual	26	103.191	3.969		
Total	77	2558.741			

Tables of means

Variate: Yield

Grand mean 12.326

CULTIVAR	1	2	3	4	5	6	7
	11.380	14.109	13.379	10.047	9.875	12.256	13.451
CULTIVAR	8	9	10	11	12	13	
	11.623	20.639	8.632	13.516	12.275	9.054	

CUT_TMT	1	2	3
	10.760	8.541	17.923

CULTIVAR	CUT_TMT	1	2	3
1		11.247	4.886	18.006
2		11.809	11.016	19.501
3		13.504	11.494	15.140
4		7.903	5.140	17.098
5		7.150	7.009	15.466
6		14.140	9.148	13.481
7		12.624	6.539	21.189
8		12.765	10.455	11.647
9		19.496	15.537	26.883
10		5.213	6.369	14.315
11		10.199	12.478	21.070
12		8.273	6.595	21.957
13		5.557	4.363	17.242

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	6	26	2
e.s.e.	1.0001	0.3907	1.5242

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	6	26	2
l.s.d.	3.0816	1.1358	4.3724

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	1	0.5400	4.4
REP.WPLOT	12	1.4143	11.5
REP.WPLOT.SPLOT	26	1.9922	16.2

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean
9	20.64 a
2	14.11 b
11	13.52 b
7	13.45 b
3	13.38 b
12	12.28 bc
6	12.26 bc
8	11.62 bcd
1	11.38 bcd
4	10.05 cd
5	9.88 cd
13	9.05 d
10	8.63 d

===== Testing differences between CUTTING TREATMENT means =====

Fisher's protected least significant difference test

CUT_TMT

	Mean
3	17.92 a
1	10.76 b
2	8.54 c

ADDENDUM A2

========SORGHUM TRIAL: DECEMBER PLANTING (DWD): SIX WEEKS REGROWTH ========

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	1	929502.	929502.	3.28	
REP.WPLOT stratum					
CULTIVAR	12	101346384.	8445532.	29.84	<.001
Residual	12	3395875.	282990.	0.43	
REP.WPLOT.SPLOT stratum					
CUT_TMT	3	235843811.	78614604.	119.17	<.001
CULTIVAR.CUT_TMT	36	90577264.	2516035.	3.81	<.001
Residual	39	25728474.	659704.		
Total	103	457821310.			

Tables of means

Variate: Yield

Grand mean 2629.

CULTIVAR	1	2	3	4	5	6	7
	2812.	2952.	3376.	1976.	1788.	3535.	3156.
CULTIVAR	8	9	10	11	12	13	
	3191.	4874.	1303.	2550.	2068.	1389.	

CUT_TMT	1	2	3	4
	2756.	3970.	3898.	137.

CULTIVAR	CUT_TMT	1	2	3	4
1		3044.	3379.	4656.	168.
2		1953.	4661.	5138.	57.
3		3001.	4582.	5820.	99.
4		2626.	3050.	2127.	99.
5		2149.	2536.	2422.	42.
6		4878.	4344.	4832.	85.
7		3054.	6217.	3224.	128.
8		3280.	4702.	4571.	214.
9		4412.	7862.	6938.	285.
10		1840.	2172.	1131.	71.
11		2334.	4295.	3200.	370.
12		2074.	1966.	4118.	114.
13		1176.	1840.	2499.	42.

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	8	26	2
e.s.e.	188.1	159.3	574.3

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	8	26	2
l.s.d.	579.5	455.7	1642.9

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP.WPLOT.SPLOT	39	812.2	30.9

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean
9	4874 a
6	3535 b
3	3376 bc
8	3191 bc
7	3156 bc
2	2952 c
1	2812 c
11	2549 c
12	2068 d
4	1976 d
5	1788 de
13	1389 e
10	1303 e

===== Testing differences between CUTTING TREATMENT means =====

Fisher's protected least significant difference test

CUT_TMT

	Mean	
2	3970	a
3	3898	a
1	2756	b
4	137	c

ADDENDUM A3

=========== SORGHUM TRIAL: DECEMBER PLANTING (DWD): SILAGE STAGE ===========

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	1	1.346	1.346	0.33	
REP.WPLOT stratum					
CULTIVAR	12	206.691	17.224	4.16	0.010
Residual	12	49.685	4.140	1.08	
REP.WPLOT.SPLOT stratum					
CUT_TMT	1	3216.455	3216.455	841.42	<.001
CULTIVAR.CUT_TMT	12	226.049	18.837	4.93	0.004
Residual	13	49.694	3.823		
Total	51	3749.920			

Tables of means

Variate: Yield

Grand mean 8.96

CULTIVAR	1	2	3	4	5	6	7
	9.00	9.75	7.57	8.55	7.73	6.74	10.59
CULTIVAR	8	9	10	11	12	13	
	5.82	13.44	7.16	10.54	10.98	8.62	

CUT_TMT	1	2
	16.83a	1.10b

CULTIVAR	CUT_TMT	1	2
1		17.54	0.47
2		18.00	1.50
3		13.82	1.32
4		16.35	0.75
5		15.06	0.41
6		13.17	0.31
7		19.78	1.41
8		9.33	2.32
9		25.98	0.91
10		13.53	0.78
11		18.31	2.76
12		21.33	0.63
13		16.55	0.69

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	4	26	2
e.s.e.	1.017	0.383	1.411

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	4	26	2
l.s.d.	3.135	1.171	4.224

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	1	0.228	2.5
REP.WPLOT	12	1.439	16.1
REP.WPLOT.SPLOT	13	1.955	21.8

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean
9	13.442 a
12	10.979 ab
7	10.595 abc
11	10.535 abc
2	9.751 bcd
1	9.003 bcd
13	8.621 bcde
4	8.549 bcde
5	7.734 cde
3	7.570 cde
10	7.158 de
6	6.741 de
8	5.824 e

===== Testing differences between CUTTING TREATMENT means =====

Fisher's protected least significant difference test

CUT_TMT

	Mean
1	16.83 a
2	1.10 b

ADDENDUM A 4

======== SORGHUM TRIAL: JANUARY PLANTING (DWD): TOTAL DM PRODUCTION=========

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	7.040E+08	3.520E+08	25.67	
REP.*Units* stratum					
CULTIVAR	12	3.698E+08	3.082E+07	2.25	0.026
CUT_TMT	2	2.899E+09	1.449E+09	105.70	<.001
CULT_CUT_TMT	24	2.884E+08	1.202E+07	0.88	0.972
Residual	51	1.042E+09	1.371E+07		
Total	115	5.303E+09			

Tables of means

Variate: Yield

Grand mean 8343.

CULTIVAR	1	2	3	4	5	6	7	8	9	10
	7458.	9559.	8826.	5957.	8857.	9245.	6703.	7606.	11584.	6960.

CULTIVAR	11	12	13
	9181.	10289.	6645.

CUT_TMT	1	2	3
	5159.	4950.	15019.

CULTIVAR	CUT_TMT 1	2	3
1	5549.	3767.	13058.
2	7442.	5400.	15836.
3	5444.	3329.	13499.
4	2354.	2903.	12613.
5	4865.	5136.	16570.
6	5594.	4830.	17312.
7	3330.	4544.	12236.
8	4921.	3698.	14200.
9	7679.	4973.	22100.
10	3013.	5592.	12275.
11	6725.	4661.	16155.
12	7636.	4881.	18350.
13	2519.	6425.	10991.

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	9	39	3
d.f.	76	76	76
e.s.e.	1.0336	0.7207	2.598

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	9	39	3
d.f.	76	76	76
l.s.d.	3.0170	2.046	7.3771

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	2	3.2816	39.2
REP.*Units*	51	4.5009	53.7

ADDENDUM A5

========= SORGHUM TRIAL: JANUARY PLANTING (DWD): SIX WEEKS REGROWTH=========

Analysis of variance

Variate: YIELD

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	51482377.	25741189.	30.01	
REP.WPLOT stratum					
CULTIVAR	12	43500719.	3625060.	4.23	0.001
Residual	24	20587885.	857829.	0.59	
REP.WPLOT.SPLOT stratum					
CUT_TMT	2	271340517.	135670258.	93.55	<.001
CULTIVAR.CUT_TMT	24	52162482.	2173437.	1.50	0.111
Residual	52	75415198.	1450292.		
Total	116	514489178.			

Tables of means

Variate: YIELD

Grand mean 1720.

CULTIVAR	1	2	3	4	5	6	7
	1850.	2481.	1815.	785.	1622.	1865.	1110.
CULTIVAR	8	9	10	11	12	13	
	1640.	2560.	1004.	2242.	2545.	840.	

CUT_TMT	1	2	3
	1254.	3774.	131.

CULTIVAR	CUT_TMT	1	2	3
1		1413.	4040.	96.
2		1672.	5633.	137.
3		1070.	4216.	158.
4		784.	1467.	103.
5		1012.	3737.	117.
6		1585.	3892.	117.
7		1007.	2220.	103.
8		1002.	3672.	247.
9		2432.	5027.	220.
10		849.	2076.	89.
11		2451.	4130.	144.
12		842.	6684.	110.
13		188.	2263.	69.

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	9	39	3
e.s.e.	308.7	192.8	695.3

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	9	39	3
l.s.d.	901.1	547.2	1973.1

Stratum standard errors and coefficients of variation

Variate: YIELD

Stratum	d.f.	s.e.	cv%
REP.WPLOT.SPLOT	52	1204.3	70.0

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean
9	2560 a
12	2545 a
2	2481 ab
11	2242 ab
6	1865 abc
1	1850 abc
3	1815 abc
8	1640 bcd
5	1622 bcd
7	1110 cd
10	1004 cd
13	840 d
4	785 d

===== Testing differences between CUTTING TREATMENT means =====

Fisher's protected least significant difference test

CUT_TMT

	Mean
2	3774 a
1	1254 b
3	131 c

ADDENDUM A6

============ SORGHUM TRIAL: JANUARY PLANTING (DWD): SILAGE STAGE ============

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	1.243E+09	6.216E+08	27.20	
REP.Cult stratum					
CULTIVAR	12	3.449E+08	2.874E+07	1.26	0.304
Residual	24	5.484E+08	2.285E+07		
Total	38	2.136E+09			

Tables of means

Variate: Yield

Grand mean 15015.

CULTIVAR	1	2	3	4	5	6	7
	13058.	15836.	13499.	12613.	16570.	17312.	12236.

CULTIVAR	8	9	10	11	12	13
	14200.	22100.	12275.	16155.	18350.	10991.

Standard errors of means

Table	CULTIVAR
rep.	3
d.f.	24
e.s.e.	2759.9

Least significant differences of means (5% level)

Table	CULTIVAR
rep.	3
d.f.	24
l.s.d.	8055.5

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	2	6914.6	46.1

REP.Cult	24	4780.3	31.8

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

Fisher's protected LSD is not calculated as variance ratio for CULTIVAR is not significant.

ADDENDUM A7

======= SORGHUM TRIAL: FEBRUARY PLANTING (DWD): TOTAL DM PRODUCTION =======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	4.4287	2.2144	2.70	
REP.WPLOT stratum					
CULTIVAR	12	15.9102	1.3259	1.61	0.154
Residual	24	19.7124	0.8213	0.96	
REP.WPLOT.SPLOT stratum					
CUT_TMT	2	11.8571	5.9285	6.96	0.002
CULTIVAR.CUT_TMT	24	46.6659	1.9444	2.28	0.006
Residual	52	44.2658	0.8513		
Total	116	142.8401			

Tables of means

Variate: Yield

Grand mean 2.386

CULTIVAR	1	2	3	4	5	6	7
	2.761	1.760	2.678	2.846	2.173	2.775	2.925

CULTIVAR	8	9	10	11	12	13
	2.253	1.863	2.182	2.473	2.232	2.092

CUT_TMT	1	2	3
	1.944	2.683	2.529

CULTIVAR	CUT_TMT 1	2	3
1	1.565	4.215	2.502
2	1.071	1.822	2.386
3	2.162	2.291	3.582
4	2.087	3.800	2.651
5	2.172	2.673	1.675
6	3.148	2.163	3.014
7	1.578	4.021	3.176
8	3.274	2.127	1.357
9	1.703	1.802	2.083
10	1.251	3.316	1.978
11	2.655	1.528	3.236
12	1.092	2.866	2.738

13		1.517	2.257	2.502

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	9	39	3
e.s.e.	0.3021	0.1477	0.5327

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	9	39	3
l.s.d.	0.8818	0.4193	1.5117

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	2	0.2383	10.0
REP.WPLOT	24	0.5232	21.9
REP.WPLOT.SPLOT	52	0.9226	38.7

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

Fisher's protected LSD is not calculated as variance ratio for CULTIVAR is not significant.

===== Testing differences between CUTTING TREATMENT means =====

Fisher's protected least significant difference test

CUT_TMT

	Mean
2	2.683 a
3	2.529 b
1	1.944 c

ADDENDUM B1

======== SORGHUM TRIAL: DECEMBER PLANTING (NGT): SIX WEEKLY REGROWTH========

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	9.1461	3.0487	4.65	
REP.WPLOT stratum					
CULTIVAR	11	36.8581	3.3507	5.11	<.001
Residual	33	21.6427	0.6558	0.69	
REP.WPLOT.SPLOT stratum					
CUT	2	154.2442	77.1221	80.83	<.001
CULTIVAR.CUT	22	38.7341	1.7606	1.85	0.028
Residual	72	68.7003	0.9542		
Total	143	329.3256			

Tables of means

Variate: Yield

Grand mean 2.132

CULTIVAR	1	2	3	4	5	6	7
	2.229	2.078	2.157	1.328	1.719	2.574	1.443

CULTIVAR	8	9	10	11	12
	2.890	2.836	1.535	2.453	2.339

CUT	1	2	3
	1.264	3.587	1.545

CULTIVAR	CUT	1	2	3
1		1.286	4.079	1.323
2		1.211	3.683	1.342
3		1.432	3.626	1.412
4		0.881	1.916	1.188
5		1.381	2.067	1.711
6		2.044	4.136	1.543
7		0.969	2.097	1.264
8		1.224	5.150	2.295
9		1.501	5.574	1.433
10		0.871	2.314	1.419
11		1.226	4.389	1.744
12		1.146	4.008	1.865

Standard errors of means

Table	CULTIVAR	CUT	CULTIVAR CUT
rep.	12	48	4
e.s.e.	0.2338	0.1410	0.4884
d.f.	33	72	103.36

Least significant differences of means (5% level)

Table	CULTIVAR	CUT	CULTIVAR CUT
rep.	12	48	4
l.s.d.	0.6726	0.3975	1.3769
d.f.	33	72	103.36

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	0.2910	13.7
REP.WPLOT	33	0.4676	21.9
REP.WPLOT.SPLOT	72	0.9768	45.8

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean	
8	2.890	a
9	2.836	a
6	2.574	ab
11	2.453	ab
12	2.339	abc
1	2.229	abc
3	2.157	bcd
2	2.078	bcde
5	1.719	cdef
10	1.535	def
7	1.443	ef
4	1.328	f

===== Testing differences between CUT means =====

Fisher's protected least significant difference test

CUT

	Mean	
2	3.587	a
3	1.545	b
1	1.264	b

ADDENDUM B2

====== SORGHUM TRIAL: DECEMBER PLANTING (NGT): GRAZING STAGE ======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	23.767	7.922	7.19	
REP.WPLOT stratum					
CULTIVAR	11	71.283	6.480	5.88	<.001
Residual	33	36.360	1.102	1.00	
REP.WPLOT.SPLOT stratum					
CUT	1	60.884	60.884	55.48	<.001
CULTIVAR.CUT	11	27.042	2.458	2.24	0.034
Residual	36	39.509	1.097		
Total	95	258.846			

Tables of means

Variate: Yield

Grand mean 3.88

CULTIVAR	1	2	3	4	5	6	7
	4.87	4.81	3.36	2.06	3.50	4.88	3.63
CULTIVAR	8	9	10	11	12		
	3.92	4.86	2.88	4.32	3.52		

CUT	1	2
	3.09a	4.68b

CULTIVAR	CUT	1	2
1		4.57	5.16
2		4.22	5.40
3		2.47	4.25
4		1.45	2.67
5		2.79	4.22
6		4.90	4.86
7		2.15	5.11
8		1.88	5.95
9		3.93	5.79
10		2.53	3.23
11		3.75	4.90
12		2.41	4.63

Standard errors of means

Table	CULTIVAR	CUT	CULTIVAR CUT
rep.	8	48	4
e.s.e.	0.371	0.151	0.524
d.f.	33	36	68.86

Least significant differences of means (5% level)

Table	CULTIVAR	CUT	CULTIVAR CUT
rep.	8	48	4
l.s.d.	1.068	0.434	1.502
d.f.	33	36	68.86

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	0.575	14.8
REP.WPLOT	33	0.742	19.1
REP.WPLOT.SPLOT	36	1.048	27.0

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean	
6	4.882	a
1	4.866	a
9	4.861	a
2	4.814	a
11	4.323	ab
8	3.916	abc
7	3.628	bc
12	3.522	bc
5	3.504	bc
3	3.357	bc
10	2.883	cd
4	2.062	d

ADDENDUM B3

======= SORGHUM TRIAL: DECEMBER PLANTING (NGT): SILAGE STAGE =======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	552.86	184.29	12.00	
REP.PLOT stratum					
CULTIVAR	11	249.07	22.64	1.47	0.188
Residual	33	506.61	15.35		
Total	47	1308.54			

Tables of means

Variate: Yield

Grand mean 11.86

CULTIVAR	1	2	3	4	5	6	7
	11.35	13.56	10.45	9.31	10.65	14.70	8.44
CULTIVAR	8	9	10	11	12		
	8.97	15.15	11.63	13.47	14.60		

Standard errors of means

Table	CULTIVAR
rep.	4
d.f.	33
e.s.e.	1.959

Least significant differences of means (5% level)

Table	CULTIVAR
rep.	4
d.f.	33
l.s.d.	5.637

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	3.919	33.1
REP.PLOT	33	3.918	33.0

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

Fisher's protected LSD is not calculated as variance ratio for CULTIVAR is not significant.

ADDENDUM B4

======SORGHUM TRIAL: DECEMBER PLANTING (NGT): TOTAL DM PRODUCTION======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	3.373E+08	1.124E+08	12.63	
REP.Cult.Cut stratum					
CULTIVAR	11	3.575E+08	3.250E+07	3.65	<.001
CUT_TMT	2	7.744E+08	3.872E+08	43.49	<.001
CULTIVAR.CUT_TMT	22	1.447E+08	6.577E+06	0.74	0.790
Residual	105	9.348E+08	8.903E+06		
Total	143	2.549E+09			

Tables of means

Variate: Yield

Grand mean 8673.

CULTIVAR	1	2	3	4	5	6	7
	9256.	9807.	7877.	5805.	7606.	10727.	6674.

CULTIVAR	8	9	10	11	12
	8488.	11126.	7334.	9825.	9556.

CUT_TMT	1	2	3
	6396.	7769.	11856.

CULTIVAR	CUT_ TMT 1	2	3
1	6688.	9732.	11348.
2	6236.	9627.	13558.
3	6470.	6713.	10449.
4	3985.	4124.	9305.
5	5159.	7008.	10653.
6	7723.	9763.	14695.
7	4330.	7255.	8436.
8	8669.	7831.	8966.
9	8508.	9721.	15151.
10	4604.	5767.	11631.
11	7359.	8646.	13471.
12	7019.	7045.	14604.

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	12	48	4
d.f.	105	105	105
e.s.e.	861.3	430.7	1491.9

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	12	48	4
d.f.	105	105	105
l.s.d.	2415.3	1207.7	4183.5

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	1767.1	20.4
REP.Cult.Cut	105	2983.8	34.4

===== Testing differences between CULTIVAR means =====

Fisher's Protected Least Significant Difference test

CULTIVAR

```
            Mean
  9        11126 |
  6        10727 | |
 11         9825 | | |
  2         9807 | | |
 12         9556 | | | |
  1         9256 | | | |
  8         8488   | | | |
  3         7877     | | | |
  5         7606     | | | |
 10         7334       | | |
  7         6674         | |
  4         5805           |
```

ADDENDUM B5

====== SORGHUM TRIAL: JANUARY PLANTING (NGT): SIX WEEKS REGROWTH======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	3.31484	1.10495	4.39	
REP.WPLOT stratum					
CULTIVAR	11	7.93421	0.72129	2.87	0.009
Residual	33	8.30173	0.25157	2.66	
REP.WPLOT.SPLOT stratum					
CUT	1	9.97751	9.97751	105.42	<.001
CULTIVAR.CUT	11	1.83461	0.16678	1.76	0.099
Residual	36	3.40712	0.09464		
Total	95	34.77000			

Tables of means

Variate: Yield

Grand mean 0.868

CULTIVAR	1	2	3	4	5	6	7
	0.739	0.900	0.912	0.497	0.741	1.192	0.463
CULTIVAR	8	9	10	11	12		
	1.055	1.300	0.443	1.246	0.933		

CUT	1	2
	0.546a	1.191b

CULTIVAR	CUT	1	2
1		0.352	1.126
2		0.460	1.340
3		0.554	1.269
4		0.352	0.642
5		0.595	0.887
6		0.911	1.473
7		0.283	0.642
8		0.482	1.627
9		0.936	1.664
10		0.309	0.577
11		0.787	1.704
12		0.528	1.337

Standard errors of means

Table	CULTIVAR	CUT	CULTIVAR CUT
rep.	8	48	4
e.s.e.	0.1773	0.0444	0.2080
d.f.	33	36	55.32

Least significant differences of means (5% level)

Table	CULTIVAR	CUT	CULTIVAR CUT
rep.	8	48	4
l.s.d.	0.5102	0.1274	0.5895
d.f.	33	36	55.32

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	0.2146	24.7
REP.WPLOT	33	0.3547	40.8
REP.WPLOT.SPLOT	36	0.3076	35.4

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean	
9	1.3004	a
11	1.2456	ab
6	1.1920	ab
8	1.0546	ab
12	0.9326	abc
3	0.9120	abc
2	0.9000	abc
5	0.7410	bc
1	0.7392	bc
4	0.4969	c
7	0.4626	c
10	0.4431	c

ADDENDEM B6

======= SORGHUM TRIAL: JANUARY PLANTING (NGT): GRAZING STAGE=======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	54.858	18.286	8.08	
REP.PLOT stratum					
CULTIVAR	11	69.573	6.325	2.79	0.011
Residual	33	74.708	2.264		
Total	47	199.139			

Tables of means

Variate: Yield

Grand mean 3.01

CULTIVAR	1	2	3	4	5	6	7
	2.31	3.32	2.51	1.49	2.58	5.88	2.50
CULTIVAR	8	9	10	11	12		
	2.74	4.71	1.57	2.78	3.72		

Standard errors of means

Table	CULTIVAR
rep.	4
d.f.	33
e.s.e.	0.752

Least significant differences of means (5% level)

Table	CULTIVAR
rep.	4
d.f.	33
l.s.d.	2.165

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	1.234	41.0
REP.PLOT	33	1.505	50.0

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean	
6	5.876	a
9	4.713	ab
12	3.721	abc
2	3.319	bcd
11	2.781	bcd
8	2.744	bcd
5	2.585	bcd
3	2.510	cd
7	2.500	cd
1	2.312	cd
10	1.574	cd
4	1.488	d

ADDENDUM B7

======= SORGHUM TRIAL: JANUARY PLANTING (NGT) SILAGE STAGE =======

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	206.252	68.751	16.37	
REP.PLOT stratum					
CULTIVAR	11	136.152	12.377	2.95	0.008
Residual	33	138.599	4.200		
Total	47	481.004			

Tables of means

Variate: Yield

Grand mean 5.350

CULTIVAR	1	2	3	4	5	6	7
	5.602	4.597	4.196	2.957	4.088	10.567	5.323
CULTIVAR	8	9	10	11	12		
	3.847	7.180	4.196	6.170	5.476		

Standard errors of means

Table	CULTIVAR
rep.	4
d.f.	33
e.s.e.	1.025

Least significant differences of means (5% level)

Table	CULTIVAR
rep.	4
d.f.	33
l.s.d.	2.264

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	2.394	43.4
REP.PLOT	33	2.049	29.42

===== Testing differences between CULTIVAR means =====

Fisher's protected least significant difference test

CULTIVAR

	Mean	
6	10.567	a
9	7.180	
11	6.170	
1	5.602	
12	5.476	
7	5.323	
2	4.597	
3	4.196	
10	4.400	
5	5.497	
8	3.847	
4	2.957	

ADDENDUM B8

======== SORGHUM TRIAL: JANUARY PLANTING (NGT): TOTAL DM PRODUTION ========

Analysis of variance

Variate: Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	110436126.	36812042.	13.84	
REP.Cult.Cut stratum					
CULTIVAR	11	189968984.	17269908.	6.49	<.001
CUT_TMT	2	322361344.	161180672.	60.58	<.001
CULTIVAR.CUT_TMT	22	72000115.	3272733.	1.23	0.240
Residual	105	279368052.	2660648.		
Total	143	974134622.			

Tables of means

Variate: Yield

Grand mean 3365.

CULTIVAR	1	2	3	4	5	6	7
	3131.	3238.	2843.	1813.	2718.	6276.	2916.

CULTIVAR	8	9	10	11	12
	2900.	4831.	2218.	3814.	3688.

CUT_TMT	1	2	3
	1737.	3010.	5350.

CULTIVAR	CUT_TMT 1	2	3
1	1478.	2312.	5602.
2	1800.	3319.	4597.
3	1824.	2510.	4196.
4	994.	1488.	2958.
5	1482.	2585.	4088.
6	2384.	5876.	10567.
7	925.	2500.	5323.
8	2109.	2744.	3847.
9	2600.	4713.	7180.
10	886.	1574.	4193.
11	2491.	2781.	6170.
12	1865.	3721.	5476.

Standard errors of means

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	12	48	4
d.f.	105	105	105
e.s.e.	470.9	235.4	815.6

Least significant differences of means (5% level)

Table	CULTIVAR	CUT_TMT	CULTIVAR CUT_TMT
rep.	12	48	4
d.f.	105	105	105
l.s.d.	1320.4	660.2	2287.0

Stratum standard errors and coefficients of variation

Variate: Yield

Stratum	d.f.	s.e.	cv%
REP	3	1011.2	30.0
REP.Cult.Cut	105	1631.1	48.5

===== Testing differences between CULTIVAR means =====

Fisher's Protected Least Significant Difference test

CULTIVAR

```
   Mean
    6      6276
    9      4831 |
   11      3814 | |
   12      3688 | |
    2      3238   | |
    1      3131   | | |
    7      2916   | | |
    8      2900   | | |
    3      2843   | | |
    5      2718   | | |
   10      2218     | |
    4      1813       |
```