SUMMER SUPPLEMENTATION OF BEEF CATTLE ON VELD AND KIKUYU PASTURES

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Submitted in partial fulfilment
of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

in the Discipline of Grassland Science,
Faculty of Science and Agriculture
University of KwaZulu-Natal
PIETERMARITZBURG
April 2004

DECLARATION OF ORIGINALITY

I, Richard Norman Reynolds hereby declare that the research reported in this thesis is the result of my own investigations, except where acknowledged, and has not, in its entirety or in part, been submitted to any University or Institution for degree purposes.

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DISCLAIMER

The use of trade names in this discussion is neither an endorsement nor an indictment of any named product

ACKNOWLEDGMENTS

I thank and recognize the following people and organizations for their invaluable support through the period of writing this thesis:

My primary supervisor Professor Pete Zacharias for his time, patience, insight, expertise and enthusiasm throughout this study. It has been an honor to be associated with him and to benefit from his amazing insight into the many issues that daunted me.

My supervisor Mark Darroch. His opinions, intellect and ability to explain financial concepts to a Grassland Scientist were most appreciated, particularly when time was tight.

Many thanks to my parents Mary and Robin for the opportunities you have opened to me and your unstinting support in all the tasks I attempt. I am proud to be your son.

To Voermol Feeds, Dr Willie Smith and Mr Stephan Breytenbach for their support and funding of the trial, and patience while I completed the writeup.

Many thanks to the staff in the Discipline of Grassland Science; Chippie duToit, Maureen Goddard and Gerry Naiken for their enthusiasm and support through the administration and running of the trial. Without your contributions none of this would have been possible.

The staff of the KwaZulu-Natal Department of Agriculture (Grassland Science section) and in particular Dr Pete Bartholomew for their support and enthusiasm for this project.

A special thanks to Melanie Glaum for her enthusiastic support, as the task ahead grew bigger - your unstinting encouragement and never ending support pulled me onwards and upwards.

Finally, to the fellow post graduates who made this period in my life so stimulating, Brent Forbes, Coco MacGregor, Wolfie Kanz and Donovan Kotze. Thanks, it was great.

ABSTRACT

In KwaZulu-Natal the production of beef in summer from veld is a common enterprise. Many techniques are available to optimise the productivity of this enterprise, from improving the quality of the grazing resource (planted pastures) to improving the diet of animals using nutritional supplements. To gain an insight into the production potential and financial returns possible from such improvements a trial was established at the Ukulinga Research Farm during two consecutive summer growing seasons (1997-1998 and 1998-1999). The aim was to determine the optimum beef production system for the area from both veld and kikuyu pastures. To evaluate the benefits of supplying supplementary nutrition, four alternate feed supplements, namely: 1) a Standard commercially available molasses-based protein/mineral/energy supplement; 2) a Brewers grain based protein/mineral/energy supplement, and two supplements consisting of the Brewers grain ration with either; 3) Avoparcin (an additive that improves dietary energy) or 4) Bentonite (an additive that increases the bypass of protein) were compared. As stocking rate has been shown to influence the quality of the diet consumed, the kikuyu pasture was grazed at both the recommended (1.92 LSU ha^{-1}) and half the recommended stocking rate for the region. In addition, a commercial hormonal implant was applied to half of the cattle in each treatment.

Grazing was monitored using the falling plate disc meter to measure pasture bulk density and laboratory analyses of herbage grab samples for digestibility and crude protein percentage. Cattle were weighed on a weekly basis and their condition was scored prior to slaughter. All enterprise costs and returns were recorded to facilitate financial analyses of the five treatments.

Low rainfall and high midsummer temperatures had a detrimental effect on the productivity of the grazing and hence it was difficult to optimise production in either season. In the first season, a midsummer drought decreased the quality and quantity of both veld and kikuyu, limiting mass gain during the latter part of the season. A delay in the onset of rain at the start of the second season limited the available grazing season to 121 days as opposed to 154 days, though fodder production during the season was not limited.

Trends in herbage production (quality and quantity) from veld showed moderate quality (Crude protein 7.02%; digestibility 50.2%) with an average available herbage of 1670 kg DM ha^{-1}. As anticipated, kikuyu had higher quality (Crude protein 10.84%; digestibility 53.5%) and available herbage (2730 kg DM ha^{-1}). These results were similar to regional benchmarks. The variable rainfall highlighted both the drought tolerance of veld and the

minimum water requirements of kikuyu pastures. Lighter stocking rates tended to reduce the negative impact of moisture stress on Kikuyu pastures.

The best method of producing beef (averaged over two seasons) was from heavily stocked Kikuyu pastures using the Standard supplement (1107.63 kg livemass ha^{-1}). Cattle grazing veld and utilising the Avoparcin supplement produced beef at a rate of 95.96 kg ha^{-1}. In comparison, the unsupplemented cattle grazing Kikuyu produced 834.87 kg ha^{-1}, whilst veld grazing produced 64.43 kg ha^{-1}. Hormonal implants significantly ($P \leq 0.05$) improved beef production from all sources of grazing. A lack of rain limited grazing time, causing all the cattle to be marketed whilst too lean - this negatively affected live mass gain and, hence, net financial.

Although improved biological production is desirable, it is important to ensure that these gains are financially sustainable. Within the trial environment, implanted cattle fed the Standard supplement and grazing Kikuyu pastures at a high stocking rate provided the highest average gross margin of R 859.59 ha^{-1}. Changing to this production system from un-supplemented veld improved expected profit by R 632.58 ha^{-1} (averaged over both seasons). Further financial analyses indicated that beef purchase price had the greatest influence on the added profit from switching from the control treatment.

From a scientific standpoint these data are conclusive but it is important to remember that consumer pressure and concerns can often limit the introduction of production improvements. Such is the case with both hormonal implants and antibiotic feed additives (Avoparcin) although considering the impact of such limitations is speculative and beyond the scope of this trial.

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LIST OF ACRONYMS USED IN THE DISCUSSION

ADG	Average Daily Gain
AU	Animal Unit
AU ha^{-1}	Animal Unit per hectare
CP	Crude Protein
ha	hectare
kg	kilogram
kg $animal^{-1}$	kilogram per animal
kg day^{-1} $animal^{-1}$	kilogram per day per animal
kg ha^{-1}	kilogram per hectare
R kg^{-1}	Rand per kilogram

CHAPTER 1

INTRODUCTION, OBJECTIVES AND LITERATURE REVIEW

In conventional summer beef production systems, nutritional deficiencies pose substantial restrictions on attempts to optimise animal growth. Deficiencies in the quality of grazing material prevent cattle from realising their full growth potential. Feed supplements can assist in ensuring that sufficient quantities of the required nutrients are available for growth. The selection of an appropriate supplement will depend on nutritional requirements, affordability and expected net returns. New additives and ingredients that promise improved performance are regularly introduced but need to be carefully assessed in conjunction with the requirements of the animal to ensure that they match the system's needs and requirements.

In this context, a trial was established at the Ukulinga Research and Teaching Farm during two consecutive summer production seasons (1997–98 and 1998– 99) to investigate the most cost-effective way of improving the summer production of beef from veld and kikuyu (P*ennisetum clandestinum)* via supplementary diet enhancement.

The aims of the trial were to:

a) optimise beef production from veld and kikuyu;
b) evaluate the most cost-effective method of producing beef from veld and kikuyu; and
c) establish the link between animal production and the quality and quantity of grazing (veld and kikuyu pasture).

To address these aims:

a) a review of the literature pertinent to the trial was compiled (Chapter 1);
b) an assessment of the quantity and quality of the grazing (veld and kikuyu) was conducted to establish the productive potential of the grazing (Chapter 2);
c) beef production from a range of supplements was examined to establish the most effective supplement for beef production (Chapter 3); and
d) each production treatment option was critically analysed to determine which option added the most to profited relative to the veld control (Chapter 4).

1.1 Introduction

The optimization of beef production requires the efficient interaction of many factors including breed, nutrition, genetic potential and the environment. In practice, however, the most influential factor is the nutritional value of the forage consumed. Nutrition is the predominant factor influencing beef production and supersedes all others (Cheeke 1991). Nutritional quality is best evaluated by measuring animal performance (Fisher *et al.* 1995).

Cattle require a specific level of nutrients (minerals, energy and protein) for survival, maintenance and growth (Ensminger 1991). These nutrients are obtained principally from the fodder that the cattle consume, though not all forages are equal in terms of acceptability, palatability and ability to provide nutrients (Kretschmer & Pitman 1995). The discrepancies in quantity of nutrients mean that in some situations there are insufficient nutrients to meet all the requirements for growth. As nutrients become limiting, the body is unable to maintain biological processes as efficiently as usual. The first process to decline is growth, as only nutrients in excess of those required for survival are made available for growth. Should nutrient levels decline below this threshold the maintenance of secondary tissue (not essential for survival) is forfeited.

An environment where nutrient supply and demand is perfectly balanced represents the peak of nutritional management. Biologically, the rumen is confronted with a fodder supply that fluctuates both in quality and quantity, necessitating supplementation if animals are to produce and perform adequately (Meissner *et al.* 2000). The closest practical example of such a system would be a commercial beef feedlot, where nutritional requirements can be assessed and optimised for any stage of development. As a result, optimal growth rates are possible because at no stage do nutritional deficiencies occur. The cost of establishing and maintaining a feedlot is, however, relatively high. As a consequence, many beef producers cannot realise the potential benefits of optimised feed conversion ratios and average daily gains.

For most producers, a compromise would be a system that could deliver the benefits of feedlot diets but without the extensive financial, infrastructural and management responsibilities. In such a system, the cattle would obtain a substantial proportion of their diet from grazing, with supplementary feeds provided to optimise the diet. Supplementary feeding provides a balance in the diet by compensating for latent nutrient deficiencies i.e. energy, protein and minerals (Bransby 1988). The principal benefit of such a system would be that as grazing contributes to the basic roughage in the diet, supplementary feed costs would be substantially lower. Costs of infrastructure are also reduced, as feed troughs and fencing are the main expenses rather than feeding pens etc. Such a system would not be known as a feedlot, but rather a "Grasslot". Supplementation depends on the nutrient requirements and goals of a particular system, and factors such as recent feeding history, stage of growth and the financial position of the producer (Meissner *et al.* 2000). There are two primary reasons for supplementation; to correct deficiencies in the diet and to stimulate intake (Meissner *et al.* 2000). Fundamental to any successful supplementation program is the provision of an appropriate amount and ratio of nutrients in as economically efficient a manner as possible. In intensive production systems (dairies) it can be economically viable to supplement individual animals daily. Extensive production systems tend to broadly supplement for anticipated deficiencies because nutritional problems tend to be widespread and irregular. Grasslotting provides an alternative that blends the benefits of intensive dietary management with the practical logistics required for extensive systems.

1.2 Grazing systems

In summer beef production systems, a major portion of every animal's diet is grass. This fodder acts as the primary source of energy, protein, minerals and other nutrients required for growth. The quality and quantity of this material often determines the extent of production. Veld is the most common source of grazing, although the quality and quantity of this material can vary, depending on climatic, environmental and management factors. As an alternative, planted pastures can offer a more sustainable source of grazing with consistent quality and quantity, but require higher input costs.

1.2.1 Veld grazing

The most common method of producing beef in summer is from natural rangeland (veld), which provides a cheap and abundant source of fodder for grazing animals. The quality of grazing is driven principally by climatic (temperature, light and moisture) and soil factors. In tropical regions, temperature and light do not usually limit plant production (Fitzpatrick & Nix 1970). Available soil moisture acts as the dominant factor determining the rate of growth and duration of grazing (Hogan 1996). On average, the quality of veld grazing is low; in particular with respect to protein and energy, although at the beginning of the growing season quality is generally high. The variable quality of individual grass species can, however, impose nutritional challenges (Zacharias 1990). Veld grasses are adapted to many habitats and utilisation strategies (from light to heavy grazing), which influence the number of animals that can productively utilise an area. Some grasses are adapted to avoid or repress grazing through lower palatability or physical inaccessibility (Vickery 1981). These factors reduce the nutritional benefit that a ruminant can derive from particular species and, ultimately, restrict live mass gain.

To accurately estimate the number of cattle that an area can sustain, a survey of the grass species is required. Species composition plays a major role in determining the productivity, grazing capacity, duration of utilization and management practices required to maintain and improve it, such as burning and resting (Bartholomew 1996). An accurate veld condition assessment allows the estimation of a sustainable stocking rate for the area; with animal number a function of species composition, herbage yield and quality (Camp 1999).

To aid in assessing veld condition, KwaZulu-Natal has been separated into 23 Bioresource groups (Camp 1997). Each group represents an area of similar climate, topography and vegetation. For each Bioresource group, an ideal veld condition (benchmark) has been estimated that represents the desired species composition in the area. From this benchmark, the condition of veld in the same Bioresource group can be compared to indicate the relative condition realized. The farm Ukulinga falls into Bioresource Group 17 (Coastal Hinterland Thornveld), which has a theoretical ideal stocking rate of 3.0 animal units per hectare (AU ha^{-1}) (Camp 1997). The trial site was previously used for veld stocking rate trials but in the last 20 years it has only been used for winter grazing. The previous trials will have altered the species composition, with grasses adapted to light and heavy grazing predominating at different sites. These data will become evident with a more detailed examination of the veld. The veld at Ukulinga can support beef production, with average daily gains of between 0.3 and 0.4 kg ha^{-1} recorded for un-supplemented cattle for similar unreported trials (Mentis 1982).

1.2.2 Planted pastures

Should the required production potential not be possible from veld, the grazing can be improved by planting a pasture. Planted pastures offer the potential for a considerable improvement in diet quality, although these gains come with greater costs. The quality of management (e.g. stocking rates and fertilization) directly affects the nutritional value of the pasture and it is important to ensure that management inputs are adequate to ensure improved livestock production (Minson 1980; Rohweder & Albrecht 1995). The quality of management determines pasture productivity, persistence and the ultimate performance that animals are able to achieve (Tainton 1988).

1.2.2.1 Kikuyu

In the KwaZulu-Natal Midlands, *Pennisetum clandestinum* (kikuyu) is considered as an ideal pasture species for summer grazing and is used extensively in both the dairy and beef industry. Kikuyu grows best in temperatures from 16 to 26 °C (Tainton 1998) and requires at least 750 mm of moisture (Whiteman 1980). Kikuyu requires well-drained, deep soils of medium texture and it thrives on alluvial or sandy soils; provided that soil fertility is maintained at satisfactory levels (Tainton 1998).

Ukulinga is regarded as a marginal area for the production of kikuyu because of the requirement of a minimum 750 mm of moisture (Tainton 1998). Furthermore, Bransby (1983) noted a tendency for the summer rainfall to decline over the midsummer period (December January). Though the soils at Ukulinga tend to be shallow (150 - 450 mm), with high clay percentages, no physical limitations to kikuyu production have been encountered previously (Bransby 1983; Karnezos 1986).

1.2.2.2 Kikuyu quality and quantity

The nutrient content of kikuyu has been reviewed extensively, with nutritional levels in excess of those required for cattle maintenance and growth (Taylor 1949; Lesch *et al.* 1974; Bredon & Stewart 1978; Jones *et al.* 1980; Baker 1982; Minson 1982; Bransby 1983; Bartholomew 1985; Bredon *et al.* 1987; Fushai 1997). Many authors have found crude protein levels of between16 and 20% (Allwood 1994; Van Soest 1994; Reeves *et al.* 1996; Van der Merwe 1998).

Over a season, kikuyu maintains quality adequately, though a distinct decline in production is evident at the end of the growing season (Table 1.1). Overgrazing, or a lack of fertiliser and moisture, can exacerbate this decline. Of additional interest is the inverse Ca: P ratio, where a ratio of between 1:1 and 2:1 is required for optimal growth. Kikuyu, growing in the KwaZulu-Natal Midlands was found to have an average Ca: P ratio of 0.68 - 0.95: 1 (Miles *et al.* 2000). The ability of animals to take up Ca from kikuyu has also been reported to be severely restricted due to high oxalate levels in the leaves (Miles *et al.* 2000).

Table 1.1 Chemical composition, digestible protein, energy and TDN of kikuyu pasture (adapted from Bredon *et al.* 1987)

Season	CP (%)	DCP (%)	ME (%)	TDN (%)	DOM (%)	CF (%)	Ca g kg^{-1}	P g kg^{-1}	Ca: P g kg^{-1}
Kikuyu									
Spring	11.5	6.8	8.55	57	54.9	32.0	1.8	3.2	0.56
Summer	18.0	12.2	9.15	61	58.7	29.0	3.2	3.5	0.91
Autumn	15.0	9.7	8.70	58	55.9	30.0	2.2	3.5	0.63

Depending on fertilisation and management, the dry matter yield of kikuyu can range from 5 - 8 t DM ha^{-1} at low levels of Nitrogen (N) fertilisation (60-150 kg N ha^{-1}), to an average production of 12 t DM ha^{-1} (Cross 1979), and to beyond 16 t DM ha^{-1} with heavy N fertilisation (267 - 375 kg N ha^{-1}) (Dugmore 1995).

The fertilization requirements of kikuyu pastures are related to environmental conditions and the level of production required (Miles 1998). Generally, kikuyu is fertilised annually with 250-500 kg N ha^{-1}, maintained at a minimum soil test level of 140 mg l^{-1} potassium (K) and 10-18 mg l^{-1} phosphorous (P) (Miles 1998). The total nitrogen fertiliser requirement needs to be split over several applications through the season to minimise volatilisation losses.

Due to its resilient growth habit and persistence, it is believed that very little management is required to maintain the productivity of kikuyu. As long as irrigation and fertilization rates are adequate, the most important production variable is stocking rate. Defoliation of kikuyu should aim to optimise forage quality. Recent studies have shown that organic matter, digestibility, protein levels and some minerals are maximised when kikuyu is utilised at a level of 4 leaves per tiller, with a pasture height after grazing of roughly 60 mm (Fulkerson & Slack 1998).

1.2.2.3 Pasture factors affecting live mass gain

Live mass gains by animals grazing on kikuyu have been surprisingly disappointing, not matching its apparently high production potential (Joyce 1974; Austin 1980; Dugmore *et al.* 1991). Several factors were examined as potential reasons for this problem.

Dugmore *et al.* (1986) found that kikuyu with crude protein levels of 20% or greater tended to reduce production. In forages with high protein levels (over 15%), energy deficiencies can result in the loss of ammonia from the rumen and its excretion as urea, causing a loss in total available nitrogen (Walker 1970; Van Soest 1994; Marais 1998). Furthermore, fodder intake is reduced when dietary urea exceeds 1.5%, suggesting that high levels of non protein nitrogen (NPN) from excessive fertilization could decrease forage intake (Wilson *et al.* 1975; Marot & Miles 2001).

Energy is primarily stored in the form of non-structural carbohydrates. In kikuyu the primary non-structural carbohydrates are fructose, glucose and sucrose (Dugmore 1998) rather than starch or fructan, which are the major energy-rich non-structural carbohydrates in temperate species. Meaker (1998) showed that energy supplementation of steers grazing kikuyu allowed significantly faster growth rates (compared to un-supplemented steers). van der Merwe (1998) suggested that feeding a low protein, high carbohydrate concentrate could contribute to a more efficient utilisation of pasture protein than a high protein diet alone.

The ratio between protein and energy is important and has been associated with lower mass production from cattle (Dugmore & du Toit 1988; Pienaar 1994; Messiner & du Preez 1997), although supplemental rations do not guarantee optimal absorption of protein and energy (Meissner & du Preez 1996).

1.3 Animal factors

Before supplementation can be critically examined, the ruminant digestive process and basic nutrient requirements of beef cattle need to be clarified to ensure that the systems considered effectively address the nutritional needs and restrictions of the animals. In terms of diet, energy and protein are the most important nutrients and are utilised in the greatest amounts, followed by important macro- and micro-nutrients.

1.3.1 Energy sources and needs

Energy provides the body with the ability to do work (NRC 1996) and is the dietary component required by cattle in the greatest amount, usually accounting for the largest proportion of feed costs (Hamilton 1997). The primary sources of energy are starch, cellulose and hemicellulose, and are gained principally through grazing.

Energy requirements are separated into maintenance and production. Maintenance is the energy intake that results in neither the nett gain nor loss of energy from the tissues of an animal (NRC 1996). Production occurs at any level of energy above that required for maintenance.

1.3.1.1 Digestion process

In the rumen, the microbial digestion of cellulose, hemicellulose and starch results in the production of energy-rich by-products called volatile fatty acids (VFAs). These VFAs are absorbed through the rumen wall and provide the major source of energy for the ruminant. Propionic acid is the key VFA (together with acetic and butyric acid) used for energy transport in the rumen. If deficient, the metabolisable energy of the forage cannot be efficiently used (Minson 1990). Studies have found that a decrease in metabolisable energy occurs as the proportion of propionic acid decreases (Blaxter 1962). The other two VFAs (acetic and butyric acid) are only efficient when there is an adequate supply of propionate or glucose.

Rumen microbes are specialized in their ability to break down either starch or cellulose. When the diet is high in roughage, the cellulose-digesting microbes multiply and dominate, while starch digesting microbes increase in a diet high in grain. The starch that is not digested in the rumen is passed on to the abomasum and small intestine where it is broken down by biological processes and absorbed.

1.3.1.2 Energy supplementation

Optimising the energy intake of cattle requires knowledge of the energy requirements of animals. Unfortunately, these data have generally been characterised from pen fed assessments that tend to fall short of anticipated responses (Agnew & Yan 2000). Dietary energy requirements are also flexible, depending on activity, age and breed (Caton & Dhuyvetter 1997). Any management or environmental factor that affects grazing time or forage availability thus has the potential to alter energy expenditure (Senft *et al.* 1987). In subtropical regions, energy is usually deficient because of the low dry matter contents of green succulent forages (Meissner *et al.* 2000) that can be transformed to dietary energy.

Energy calculations need to consider both maintenance (e.g. movement, rumination and eating) and production. When providing supplementary energy, care must be taken to anticipate a decline in grazing time (Adams 1985; Krysl & Hess 1993) because of dietary selection that could have a negative effect on nutritional intake from grazing. An increase in dietary energy tends to decrease the efficiency of nutrient use, as more energy becomes available for maintenance and growth (NRC 1984; Caton & Dhuyvetter 1996).

Providing supplemental energy to grazing ruminants generally tends to improve production regardless of its source. These improvements are in the form of improved weight gain (or reduced losses) and an improvement in body condition score (Caton & Dhuyvetter 1997).

In some situations the apparent response to energy supplementation is minimal, particularly where rumenal protein and ammonia levels are high (Van Soest 1994; Gertenbach & van Henning 1995). Supplying supplementary energy (using sugar or starch) to cattle grazing forages with high levels of nitrogen has been shown to reduce ammonia levels within the rumen because of the rapid assimilation of ammonial nitrogen to microbial protein (Van Soest 1994). This confirms that often a shortage of ATP (energy for microbial protein synthesis) is usually the main limiting factor in fresh forage diets (Fushai 1997).

1.3.2 Protein

Protein is one of the main building blocks of the body and is usually measured as crude protein (CP%). Protein is composed of amino acids and forms a major component in muscles, the nervous system and connective tissue. Adequate dietary protein is essential for maintenance, growth, lactation and reproduction (Church 1977). Protein is composed of several fractions that vary with respect to their solubility in the rumen. Rumen soluble protein is easily broken down within the rumen environment and is utilised by rumen microbes. Rumen insoluble proteins (bypass protein) pass intact through the rumen to the lower digestive tract (large intestine) where they are digested and absorbed (Hamilton 1997).

Crude protein includes both true protein and non-protein nitrogen (NPN). The digestion of a particular protein depends to a large extent on how easily it dissolves in rumen fluid. Highly soluble protein is more likely to be broken down by rumen microbes than insoluble protein. Non-protein nitrogen sources (e.g. urea, ammonia) are totally soluble in the rumen. The rumen microbes use the nitrogen released to form their own microbial protein. Microbes are continually moving (together with digesta) into the lower digestive tract, where they themselves are digested and absorbed. The rumen insoluble protein (bypass or escape protein) passes unchanged through to the lower digestive tract. Digestible bypass proteins that can be efficiently utilized are an important component in rations of fast growing beef cattle.

The activity of the rumen microbes in breaking down and reforming dietary protein has important implications for ruminants including:

1. ruminants can thrive on diets with low quality roughage as rumen microbes are able to upgrade the protein quality by manufacturing amino acids; and

2. ruminants can utilize inexpensive sources of NPN (such as urea) as protein substitutes (Church 1977).

For optimum live mass gain, a balance of rumen soluble protein and bypass protein is required. Diets with high levels of soluble protein and/or NPN might not supply adequate amounts of protein to the small intestine. Alternately, diets with high levels of bypass protein may not supply adequate amounts of nitrogen to rumen microbes for efficient microbial growth and feed digestion. Optimum diets usually contain 30-40% available bypass protein and 60-70% rumen soluble protein. Less than 30% of total protein should be in the form of NPN (Cheeke 1991).

In order for the rumen microbes to utilize NPN, sufficient soluble carbohydrates (energy) must be included in the diet (protein: energy ratio). Without adequate energy, the capacity of the microbes to utilize NPN is soon overloaded. Excess NPN can be absorbed and excreted by the animal as ammonia, although when NPN levels are too high, toxicity can occur (urea poisoning) (Hamilton 1997). Through the use of NPN and bypass protein sources, the costs of protein supplementation can be reduced. The potential for using NPN depends on the ability of the rumenal microbes to synthesize protein, the amount of bypass protein supplied by the ration ingredients and the protein requirement of the animal (Hamilton 1997).

1.3.3 Minerals

A wide range of minerals is required for growth, bone formation, reproduction and other bodily functions. Those required in fairly large amounts are called macro-minerals and include sodium (salt), calcium, phosphorous, magnesium and potassium. Those required in very small amounts are called micro- or trace minerals and include iodine, copper, zinc, sulphur and selenium. Mineral content is affected by the type and quality of the feed. Adding a broad range of supplementary minerals to a ration is usually required to ensure that the proper amounts of these elements are available to the animal (Hamilton 1997).

It has become common practice to supplement for many of the important micro- and macro-elements regardless of their actual presence in the forage. This has two benefits. Firstly, animals are assured of receiving adequate levels of all micro- and macro-minerals. Secondly, area specific deficiencies can be avoided, ensuring more consistent production over wider areas.

1.4 Supplementation

Should grazing not be able to meet nutritional requirements, the possibility of supplying nutrients from an external source can be considered. Supplementation refers to "the provision of nutrients beyond those currently available or to offset deficiencies from forage resources" (Caton & Dhuyvetter 1997; Elizalade *et al.* 1998). Supplementation aims to compensate animals during periods of nutritional stress when grazing is unable to provide sufficient nutrients (Hogan 1996).

Deficiencies of energy, protein and phosphate are commonly found in tropical pastures and are often supplemented for (de Brouwer *et al.* 1993; Gertenbach & van Henning 1995; Hogan 1996). As mentioned, the practice known as "Grasslotting" offers potential in such situations. In these systems, the veld provides an abundant source of low quality roughage, whilst the supplement contributes the additional nutrients required to optimise the diet and promote rapid live mass gain.

1.4.1 Energy supplementation

When production is limited by energy intake rather than protein, the best option is to increase energy intake directly with an energy supplement (Mathis 2003). Typically, energy supplements are less expensive per unit than protein supplements, but the response to energy supplementation can be variable and difficult to predict. A common frustration with energy supplementation is the "substitution effect" where energy supplements replace or substitute for the intake of low quality forage. In these situations, energy intake does not increase to the desired level because of a reduction in total feed intake (Mathis 2003). When high starch supplements are fed to cattle utilising low quality forages, forage intake and digestion are often suppressed, ultimately reducing the energy derived from the basal diet (Del Curto *et al.* 1990a). As a result, energy supplementation on low quality forages often makes little or no improvement in beef cattle performance. To sustain or improve forage intake and increase total daily energy intake, a supplement with a moderate level of protein is required. Conversely, producers looking to reduce forage intake should feed supplements with high levels of energy.

1.4.2 Protein supplementation

Dietary nitrogen is important because it provides a base material for the rumen microbes to synthesise amino acids and, hence, meet the host animal's amino acid requirements (Cronje 1990). Dietary nitrogen refers to nitrogen from both protein and non-protein nitrogen (NPN) sources which rumen microbe's use for the synthesis of bacterial proteins (Allwood 1994). These amino acids are transported into the small intestine as microbial protein, bypass protein and endogenous protein secreted into the intestine. The greatest influence on the amount of protein and amino acids entering the absorptive system is the level and rate of breakdown of dietary N by rumenal microbes. The balance of proteins and amino acids in the small intestine can be artificially adjusted by modifying the source of dietary protein so that less protein is degraded within the rumen, ensuring more reaches the abomasum and small intestine (Britton *et al.* 1978).

In the presence of sufficient energy, rumen microbes can synthesise microbial protein from substrates (Shirley 1986). This process upgrades forage protein to microbial protein, which has a higher concentration of essential amino acids and thus a higher biological value.

Much research has been done on the factors that allow protein to bypass the rumen and be absorbed in the small intestine (Allwood 1994). These bypass proteins improve the efficiency of rumenal nitrogen uptake and reduce nitrogen losses. Since rumen processes are energy expensive, a reduction in the level of protein requiring degradation will increase the efficiency of the degradation and hence improve protein utilisation (Shirley 1986; Orskov 1992).

Substantial improvements in live-weight gain and intake have been observed when low quality fibrous feeds are supplemented with bypass protein (Preston & Leng 1987; Leng 1990). Low quality feed has been defined as material with a dry matter digestibility lower than 45% and crude protein content below 8% (Leng 1990).

Increasing bypass protein is useful as it provides an additional source of amino acids and glucose (Cronje 1987), increases voluntary feed intake (Kemm 1965; Swart *et al.* 1971) and directly increases animal mass (Cronje 1990). Diets high in the residues of alcohol fermentation (resistant to rumen degradation) provide an excellent source of bypass protein (Orskov 1992).

When assessing the potential for protein supplementation, dietary requirements and losses need to be considered. These requirements have been separated into three classes:

1. animal requirements: Although difficult to assess accurately, standard tables are available (NRC 1984; AFRC 1993);
2. micro-organism requirements: Micro-organisms have a basic need for protein to survive. These can be obtained from information on dietary conditions, with an average of 0.72 g nett amino acid nitrogen (AAN) per mega-joule of metabolisable energy generally required (Orskov 1992); and

3. bypass protein: The contribution of bypass protein (to nett AAN) from the feed. Digestion of this protein occurs within the small intestine and is assumed to be utilised as efficiently as microbial protein (Storm & Orskov 1983; Allwood 1994).

If the dietary requirements and contributions from grazing do not balance, supplementary protein may be required, though the protein/energy balance needs to be considered.

1.4.3 **Protein/energy balance**

An imbalance between protein and energy has often been cited as the main reason for the poor internal utilisation of nitrogen and hence poor performance of animals (Dugmore & du Toit 1988; Pienaar 1994). Tainton *et al.* (1982) demonstrated that high levels of nitrogen fertiliser (over 500 kg N ha^{-1}) on kikuyu pastures tended to reduce growth in steers (increased protein:energy ratio).

The ratio between protein, energy and protein degradation influences ruminant diets because of its impact on microbial protein production and digestion in the small intestine (Owens & Bergen 1983; Newbold & Rust 1990). Ensuring the correct ratio of protein to energy does not necessarily guarantee optimal absorption rates in the small intestine. This is because variations in feeding systems, starch types, protein degradation and the synchronisation of protein and starch all influence absorption (Meissner & du Preez 1992; Meissner & du Preez 1996).

It is important to avoid simply adding energy to a diet because of the risk of substitution. In a series of studies evaluating yearling heifer gains as influenced by supplemental protein vs. energy, Clanton and Zimmerman (1970) reported variable results from year to year. In year 1,live weight gain in heifers was increased by the addition of supplemental protein but was unaffected by supplemental energy. In year 2, a protein/energy interaction was noted with the addition of energy (at low protein levels) depressing heifer gain; the addition of energy at high levels of protein increased gain. In digestion studies, increased energy at low levels of supplemental protein decreased low-quality roughage intake and digestibility. At high levels of supplemental protein, increasing energy had little effect on the intake and digestion of low quality roughages (Del Curto *et al.* 1990b).

1.4.4 Mineral deficiencies

Mineral deficiencies are generally site specific and can be difficult to anticipate (especially for micronutrients). Eighteen macro and micro minerals have been found that influence animal growth and it is possible that several could be deficient within any grazing area. It is recognised that large areas of South Africa are deficient in phosphorus (Sielbert & Hunter 1982; Read *et al.* 1986; de Waal 1990) and sodium (Sielbert & Hunter 1982; de Waal *et al.* 1989a, 1989b). Mineral deficiencies have a detrimental effect on animal performance due to their disruption of biochemical and physical processes (NRC 1984).

1.4.5 Additives

One of the best methods of reducing feed costs is to use feed additives. Their primary effects are to improve feed efficiency and/or daily gain. Depending on the requirements of the system, additives can assist in optimising either energy or protein utilisation. Some feed additives have secondary benefits that include the reduction of acidosis, liver abscesses and foot rot problems (Stock and Mader 1984).

Each feed additive has its own particular characteristics and limitations. Using the correct amount of additive is important because too great a concentration can decrease animal performance; especially when cattle are grazing low-quality roughages.

To examine the effect of improved nutrition on beef live mass gain, in this study a standard commercially available protein-energy-mineral supplement was provided. This supplement was modified through the separate inclusion of the following additives; brewers grain (increased bypass protein), avoparcin (increased dietary energy) and bentonite (increased bypass protein) to examine the effect of adjusted protein and energy levels on live mass gain from veld and kikuyu.

1.4.5.1 Brewers grains

Brewers grains are a yeast by-product of the brewing industry and is used as a high protein feed for dairy cattle where it is fed as either dried brewers grains or spent hops (Ewing 1997). It is a cheap, high quality source of by-pass protein that is readily available to producers. Dried brewers grains have potential as a feed additive because of their low energy (2.38 mcal kg^{-1} ME), high crude protein (29.2 %) and low roughage (7.8% crude fibre) characteristics (Preston *et al.* 1973; NRC 1996).

1.4.5.2 Avoparcin

Avoparcin is a glycopeptide antibiotic used to enhance growth in cattle (Johnson *et al.* 1979) by approximately 0.12 kg day^{-1} (Lowman *et al.* 1991). It is produced by a strain of *Streptomyces candidus* with an activity against gram-positive microbes (Kunstmann *et al.* 1968).

Avoparcin improves the efficiency of microbial fermentation in the rumen by adjusting the rumen microbiology, improving the propionate to acetate ratio, decreasing methane production, and increasing organic matter digestibility (Ingle *et al.* 1978; Johnson *et al.* 1979; Flachowsky *et al.* 1990; MacGregor & Armstrong 1984). Avoparcin also improves the digestion of protein and the absorption of essential amino acids in the small intestine (Sutton *et al.* 1994). Avoparcin improves feed conversion efficiency and hence reduces feed intake (Ali Haimoud *et al.* 1996).

Since it has been reported that kikuyu is energy deficient (Marias 1998) the addition of Avoparcin might improve the live mass gain of cattle grazing kikuyu through its action on metabolic energy utilisation in the rumen.

1.4.5.3 Bentonite

Buffers neutralize rumenal acids and maintain a higher pH in the rumen when diets high in grain are fed, resisting the decrease in rumen pH caused by digestive acids. Furthermore, they reduce the incidence of acidosis on high grain diets by improving fibre digestion. Additives that are used as buffers include sodium bicarbonate, limestone and sodium bentonite (Stock & Mader 1984). The principal effect of these buffers is to depress protozoal numbers by interfering with the ciliate motion of propulsion. The consequent defaunation (loss of protozoa from the rumen) results in a nutritional boost to the small intestine (Wallace & Newbold 1991).

Bentonite is a colloidal hydrated aluminium silicate (clay) consisting principally of finely divided montmorillonite (Fenn & Leng 1990; Wallace & Newbold 1991). As a feed additive, bentonite decreases rumenal protozoal numbers, rumenal degradation of proteins and the solubility of Cu, Zn and Mg and reduces the bioavailability of Cu (Britton *et al.* 1978; Wallace & Newbold 1991; Ivan *et al.* 1992a; Ivan *et al.* 1992b). Several authors have linked Bentonite to increased wool growth, which is a recognised index of the intestinal protein:energy ratio (Bird & Leng 1984; Fenn & Leng 1990; Cobon *et al.* 1992; Ivan *et al.* 1992a). The increase in wool growth is due to a decrease in the rumenal protozoa population that increases the nett flow of amino acids from the rumen to the small intestine.

As more amino acids become available for absorption and utilisation (and less is lost to protozoal nutrition) wool growth is increased (Ivan *et al.* 1992b).

Sodium bentonite buffers against rapid changes in rumen pH by its high ion exchange capacity and ability to swell more than ten-fold when hydrated. The pH buffering effects of bentonite can be linked to a buffering effect delaying a pH increase, which could explain the favourable results found for animals adapting to high grain diets (Dunn *et al.* 1979; Aitchison *et al.* 1986). Although sodium bentonite may aid in maintaining a normal rumen pH, the mechanism of operation is unclear (Dunn *et al.* 1979).

1.4.5.4 Hormonal implants

Apart from feed additives, anabolic growth promoters can influence animal growth. Currently, the two growth promoters used extensively in South Africa are Ralgro® (38 mg zeranol) and Revalor® (estradiol-17β + trenbolone acetate) – the latter is used in this study.

These active ingredients (Estradiol-17β and trenbolone acetate) have been shown to increase the average daily gain (ADG), feed conversion efficiency, *longissimus dorsi* area and carcass protein of feedlot cattle (Bartle *et al.* 1992; Johnson *et al.* 1996). This is because the active ingredients elevate the insulin growth factor I (IGF-I) concentrations which are associated with increased muscle growth (Johnson *et al.* 1998).

Substances that influence maintenance energy requirements have great potential to improve feed conversion efficiency and so decrease the cost of beef production (Paisley *et al.* 1999). Trenbolone acetate can decrease the maintenance requirements of growing cattle by as much as 10%, depending on energy balance (Rumsey & Hammond 1990).

1.5 Conclusions

Many factors influence the summer production of beef, from a choice of forage to coping with nutritional deficiencies and the economic implications associated with a particular source of forage. Once the decision to utilise a specific area has been made, there are unique management issues that need to be resolved, such as the stocking rate, burning regime, fertilisation and irrigation.

Even if the inputs required for pasture and veld management are applied at their expected optimal levels there is no guarantee of optimal beef production because environmental conditions (temperature and rainfall) influence the growth of most forage species. Management can to some extent reduce the variability in mass gain associated with these factors (e.g. by using irrigation), but this depends on practical and financial feasibility.

Supplementation offers producers an option to realise the production benefits of improved nutrition on a more extensive basis. High quality supplements have the potential to profitably increase production by ensuring that nutritional requirements remain optimised regardless of fluctuations in the quality of the grazing.

CHAPTER 2

EVALUATING THE PRODUCTION DYNAMICS OF VELD AND KIKUYU PASTURES

2.1 Introduction

Fluctuations in the basic characteristics of a grazing sward through the growing season have a significant influence on primary production (fodder growth), and, consequently, secondary production (animal live mass gain). Understanding how the sward responds to changes in environmental and grazing pressures enables the researcher to appreciate how these variables influence primary (grass) and secondary (animal) production.

This chapter examines the factors influencing the growth and quality of veld and kikuyu, examining the reasons for fluctuations in herbage quality and quantity and their implications for animal production.

2.2 Materials and methods

2.2.1 Study site

The trial was located at the University of Natal's Research Farm - Ukulinga (Figure 2.1), located 6 km southeast of Pietermaritzburg (29°24'E, 30°24'S). Mean annual precipitation is 739 mm, mean annual temperature 18.1 °C (12.0 °C min and 24.3 °C max) and mean annual evaporation 1697 mm (Camp 1999). There is also a tendency for short midsummer droughts (Bransby 1983).

The trial was conducted over two consecutive summer seasons. The first began on 23 September 1997 and closed on 24 February 1998, (154 days). The second began on 24 November 1998 and closed on 24 March 1999 (121 days).

2.2.2 Treatment design

Three separate grazing areas were used in the trial, veld (Coastal Hinterland ThornVeld - Camp 1999) and two *Pennisetum clandestinum* (kikuyu) pastures stocked at 100% and 50% of the recommended stocking rate (see Figure 2.1 overleaf). These two kikuyu pastures were defined as Kikuyu HSR (high stocking rate) and Kikuyu LSR (low stocking rate) respectively. All paddocks (veld, Kikuyu HSR and Kikuyu LSR) were continuously grazed for the duration of each summer season.

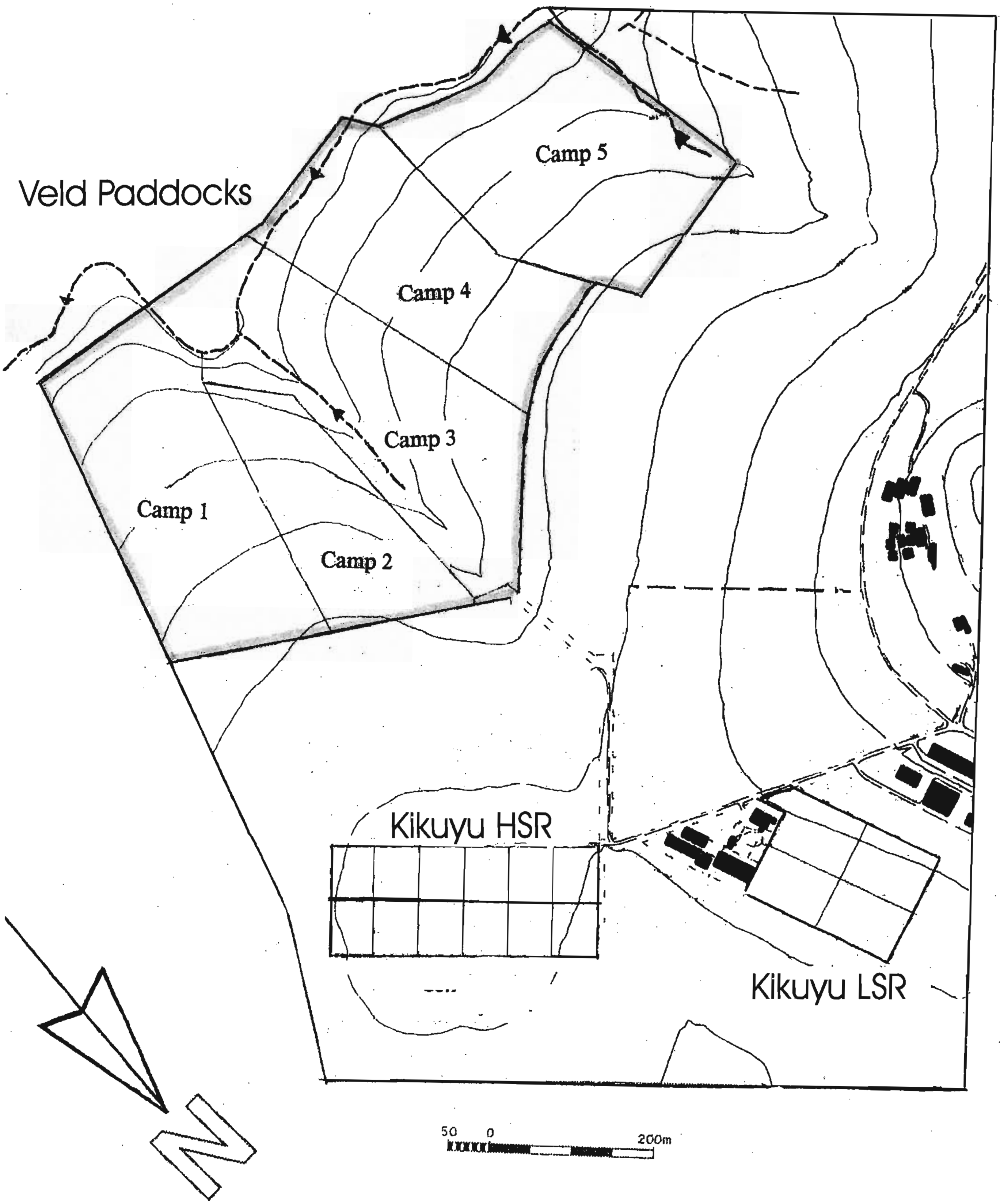

Figure 2.1 Map of Ukulinga Research and Training Farm; Veld and Kikuyu (HSR & LSR) paddocks.

2.2.2.1 Veld

The veld treatment was located on a 35-hectare (ha) area on the southeastern lowlands of the farm and was separated into five paddocks (each about 7 ha). Each paddock was stocked at a rate of 0.18 LSU ha^{-1}. Soils included Westleigh, Mispah and Glenrosa soil forms (Hughes, pers. comm. 1999, University of Natal).

2.2.2.2 Kikuyu

The two kikuyu stocking rate treatments were located in separate areas (Figure 2.1), although the management practices on these areas were identical.

The Kikuyu HSR pasture was established on 4.62 ha divided into 12 paddocks each stocked at a rate of 1.92 LSU ha^{-1}. The Kikuyu LSR pasture was established on 3.2 ha and divided into four paddocks, each initially stocked at 0.89 LSU ha^{-1}.

The dominant soil type for the Kikuyu HSR paddock was the Westleigh soil form with a depth of between 150 and 450 mm (Karnezos 1986). The Kikuyu LSR paddock had soils of the Mispah and Glenrosa type with an average depth of over 300 mm (Hughes, pers. comm. 1999, University of Natal).

2.2.3 Grazing pre-treatment and management

In both seasons, the veld and kikuyu pastures were burnt (after more than 15 mm of rain in 24 hours) prior to grazing. Burning was used to ensure that none of the previous season's dry matter could be utilised in the new following season (spring). Secondly, burning stimulated the production of fodder with uniform quality. Grazing commenced one month after burning.

Soil analyses indicated that both pastures required 125 kg Potassium ha^{-1}, 26.25 kg Phosphorous ha^{-1} and 210 kg Nitrogen ha^{-1} in each season. These were applied as Potassium chloride (50% potassium), Superphosphate (10.5% phosphorous) and Limestone Ammonium Nitrate (28% nitrogen). The application of nitrogen was split over three dressings to improve the efficiency of nitrogen utilisation.

As most local kikuyu pastures are dryland, irrigation was not used on either of the kikuyu pastures. This ensured that the experimental conditions matched local pasture management strategies.

2.2.4 Measurements

2.2.4.1 Climate

Climate is a broad term that describes the general weather conditions of a region (Garminsway 1969) that include; temperature, evaporation, rainfall, humidity and wind. Rainfall and temperature are the most important factors influencing summer beef production and thus data for these factors were recorded daily. High temperatures and low rainfall have a tendency to limit forage growth.

The Society for Range Management (1989) defined a drought as a period when precipitation is less than 75% of the average for the period. As both seasons had irregular rainfall, the potential for drought conditions in the trials must be considered.

2.2.4.2 Vegetation

Vegetation samples were harvested from both the veld and kikuyu pastures in order to determine the seasonal fluctuation in nutritional status of these grazing sources.

Completely random sampling of the veld paddocks was difficult because the stocking rate (0.18 LSU ha^{-1}) allowed cattle to selectively graze through much of the season. This meant that while several areas of veld received very little grazing pressure, areas with more palatable grass species would tend to be selected for, potentially providing a diet of higher than average quality. Completely random sampling provides an average view of veld quality, but could potentially under-estimate the nutritional contribution of the veld to the cattle should selective grazing occur. As the cattle tended to graze as a group, the boundaries of each grazing area were easy to define, providing a definite area from which random grab samples of all plant material could be collected. The kikuyu pastures were deemed to be mono-specific and thus random sampling throughout each paddock was deemed sufficient (selective grazing was unlikely to be an issue).

From each grazing treatment, ten random herbage samples were harvested per paddock every two weeks. Harvesting involved the hand plucking of herbage to a height of 20 mm, collecting sufficient herbage to fill a brown paper bag (360 mm x 190 mm). This system follows Karnezos (1986) and simulates the preferred selection of leaf blade by cattle.

All herbage samples were oven-dried at 70 °C for two days and then milled in preparation for further laboratory analysis.

2.2.4.3 Available herbage

The height to which the fodder grows in a specific time can be used to determine the fodder production (Bransby 1975; Bransby & Tainton 1977). The disc meter is a tool used to measure the standing height of herbage. A calibrated linear regression converts the height value to a dry matter (DM) yield expressed in kilograms per hectare. It is important to note that not all of this fodder is available for consumption. General recommendations suggest that the utilisation of kikuyu pastures should remain between 1500 kg ha^{-1} and 2500 kg ha^{-1}.

Sampling involved the recording of fifty random data points from all paddocks in each grazing treatment (Veld, Kikuyu HSR and Kikuyu LSR) every two weeks for the duration of each grazing season. Although the operation of a disc meter is simple (Bransby & Tainton 1977), the data from veld tends to have high statistical variation. Changes in terrain, differing growth habit of grasses (tufted vs. creeping) and the presence of other plant species (e.g. *Acacia* seedlings) tend to distort readings and introduce error.

As the trial did not include an un-grazed control (to quantify fodder production), the disc meter could only be used to determine available herbage at each sampling event.

2.2.4.4 Veld and weed assessments

Veld condition assessments and weed assessments (on pastures) both aim to identify changes in the grazing resource. Veld and pastures are dynamic entities that need to be monitored frequently to understand their productive potential.

A 1000-point survey (Camp 1999) of each of the five veld paddocks was conducted before the trial in order to establish the species composition of each paddock. These data were compared to an established benchmark (Bioresource Group 17 Coastal Hinterland Thornveld - Camp 1999) to calculate carrying capacity. Carrying capacity is a measure of the number of animals that can graze in an area and is calculated by comparing the current species composition to a benchmark of species for that area. The benchmark represents the anticipated species composition under ideal conditions and management. Differences between the benchmark and actual species composition indicate the productive potential of an area and give an insight into previous management practices (Camp 1999).

Veld condition score is a value derived from the combination of the nutritive value and abundance of each species in the assessment. This score is compared to that of the benchmark to establish the degree to which sites differ from the benchmark. The score is also used to calculate carrying capacity (Camp 1999).

Grass species have been divided into six classes based on their response to grazing:

- Decreaser - Decrease in abundance with grazing
- Increaser I - Increase in abundance with under-utilisation
- Increaser IIa - Increase in abundance with short-term overgrazing
- Increaser IIb - Increase in abundance with medium-term overgrazing
- Increaser IIc - Increase in abundance with long-term overgrazing
- Increaser III - Increase in abundance with selective overgrazing (Camp 1999).

These classes can be used to identify the reasons for changes in species composition.

To determine if the distribution of grass species between the veld paddocks was uniform, a Correspondence Analysis (CA) was conducted. This technique determines the relative association between grass species and paddocks (Ter Braak 1987).

Weed infestation in the kikuyu pastures was measured by identifying the nearest plant species at 50 random points per paddock. In total, 500 points were recorded on the Kikuyu HSR treatment pasture and 200 points on the Kikuyu LSR treatment pasture. The survey was conducted at the end of the second season, with the results presented as percentage species abundance for each grazing treatment.

2.2.5 Laboratory analyses

The forage samples for both seasons were analysed for the following characteristics:

a) Digestibility: The cellulase dry matter disappearance method (Zacharias 1986) was used to calculate digestibility. This technique establishes the level of dry matter disappearance when a forage sample is exposed to two digestive enzymes (pepsin and cellulase) in a two stage *in vitro* digestion simulation. Quantification of the amount of dry matter digested by these enzymes allows the calculation of nett digestibility by relating dry matter disappearance to the following regression equation:

$$\mathbf{Y = 1.3585X + 11.6250}$$ (Zacharias 1986)

(Y=*in vivo* digestibility and X=cellulase dry matter disappearance)

The digestibility of the forage sample can then be associated with a change in the quality of a grazing resource over the season (Zacharias 1986).

b) Crude protein analysis: Nitrogen was considered the most important element to analyse; because it can be used to calculate crude protein percentage. Forage nitrogen levels were established using the Kjeldhal method (Brenton-Jones 1991).

c) Crude protein percentage was calculated by multiplying the nitrogen level by a factor of 6.25 (Meissner *et al.* 2000).

2.2.6 Statistical analyses

Trial data were accumulated from disc metre readings, laboratory analyses, weather data and species and weed composition assessments.

The disc metre calibration data used paired height and mass values for each sample. The mass of each sample was converted to kilograms per hectare (kg ha^{-1}) and linked to the disc meter height reading through linear regressions. These calibration regressions were used to estimate biomass production from the paddocks by fitting the averaged forage height value to the relevant regression to estimate biomass production.

The cut samples were chemically analysed for both digestibility and nitrogen content. The results of these analyses were statistically analysed by averaging the laboratory values per grazing type for each sampling date and plotting them on a seasonal basis. To assess differences between seasons, paired t-tests were used to compare each measured variable (cellulase digestibility, crude protein percentages and standing crop) and to determine if statistically significant differences exist between treatments.

The daily climatic data were averaged by month (or part thereof) for rainfall, temperature and evaporation, though no further analyses were conducted. These data are presented in Appendix 1 on page 104 and discussed in section 2.3.

2.3 Results

Trends in climate, species composition, available herbage, and laboratory analyses of the three grazing treatments are described in the following sections.

2.3.1 Climate

Rainfall and temperature were erratic in Season 1 (see Figure 2.2 overleaf and Appendix 1 on page 104). Although Season 2 began with sufficient rainfall, this declined to below 75% of the long-term mean during December. Although rainfall was limited, the average temperature remained moderate (though several days recorded temperatures approaching 40 °C). Both rainfall and average temperature increased from January onwards. A total of 471 mm rainfall was received over the first season, exceeding the long-term mean for the same period.

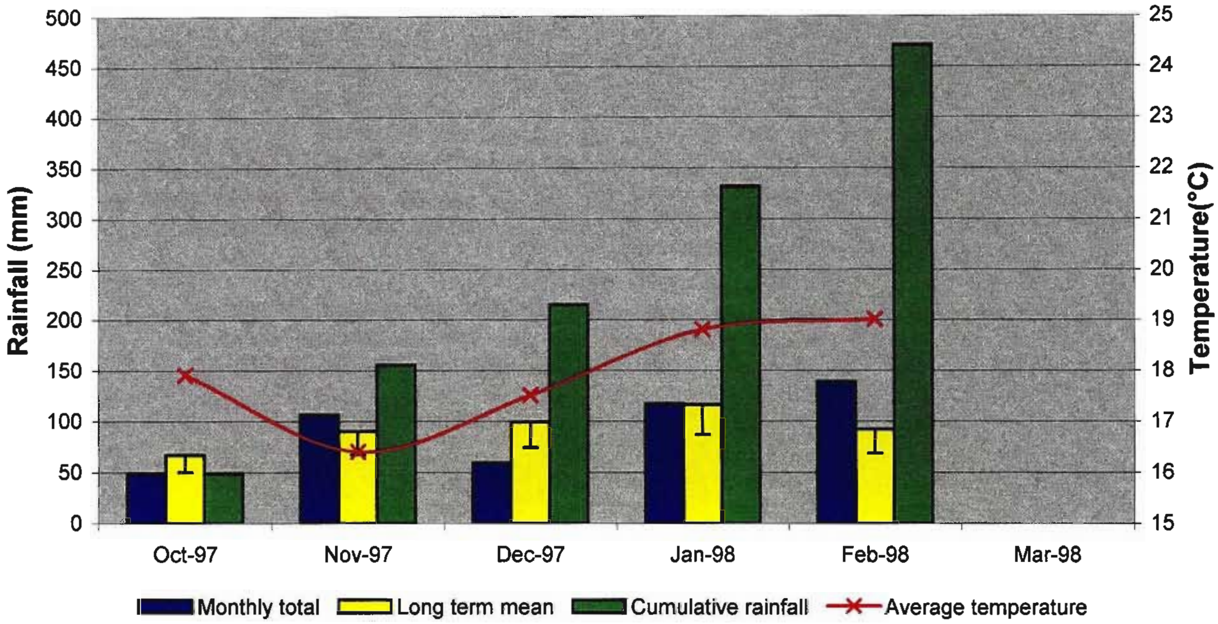

Figure 2.2 Rainfall and temperature for Season 1.

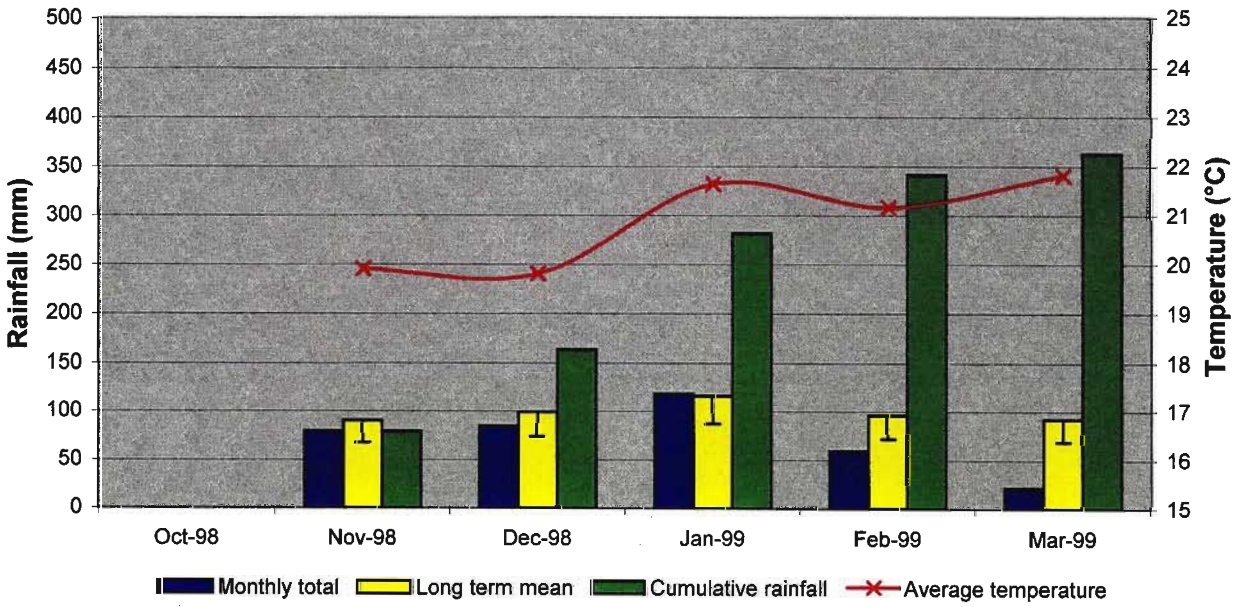

Figure 2.3 Rainfall and temperature for Season 2.

The late onset of summer rain delayed the commencement of grazing in Season 2 (see Figure 2.3 page 25). Temperatures were on average 2.5 °C warmer than for the same month in Season 1. Total rainfall (although consistent) was low and declined markedly towards the end of summer resulting in an end-of-season drought. The total summer rainfall of 362 mm was 131 mm less than the long-term mean of 493 mm. The low rainfall and higher average temperature of this season would have had a substantial negative effect on plant growth, particularly near the end of summer.

2.3.2 Species composition

The abundance of palatable species in a sward is a key factor influencing the overall quality of a grazing resource (Kreuter 1985).

2.3.2.1 Veld condition assessment

A 1 000 point veld condition assessment (Camp 1999) was conducted in each veld paddock, recording the nearest species to 1000 random points (see Appendix 2 on page 105). This survey was used to determine the carrying capacity of the veld and the degree to which individual paddocks differed.

An assessment of the species composition data on a paddock basis (see Figure 2.4 overleaf) revealed substantial differences in condition score. Only paddocks 1 and 5 had condition scores above 70% that signified veld in relatively good condition. In contrast, paddock 3 had a condition score of 63% (moderate condition) while paddocks 2 and 4 had scores of 52% and 45% respectively (poor condition). These results show that substantial differences exist between the different paddocks. The implication is that the paddocks with a higher condition score have a greater productive potential than the paddocks with lower scores (greater abundance of more nutritious species).

To determine the cause of the difference in carrying capacities, the data for each paddock were grouped according to their response to grazing (see Figure 2.5 page 28). The abundance of Increaser IIb species in all paddocks indicated generalised medium-term overgrazing, although paddock 3 had a distinctly higher proportion of these species. Paddocks 2 and 4 had a higher proportion of Increaser III species, indicating selective overgrazing in the past. Paddocks 1 and 5 had the greatest production potential due to their high levels of Decreaser species.

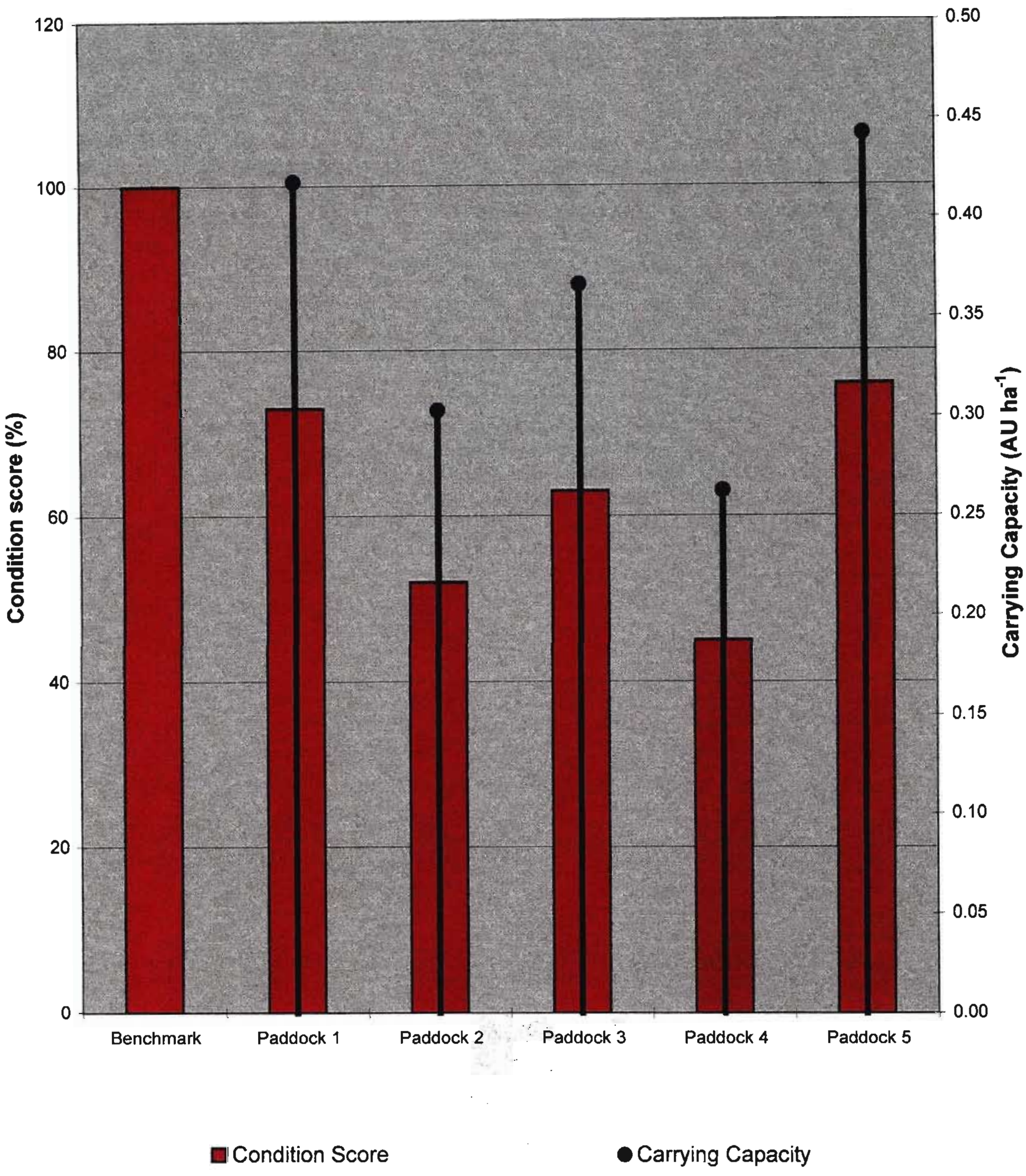

Figure 2.4 Veld condition analyses and carrying capacity (AU ha^{-1}) per veld paddock.

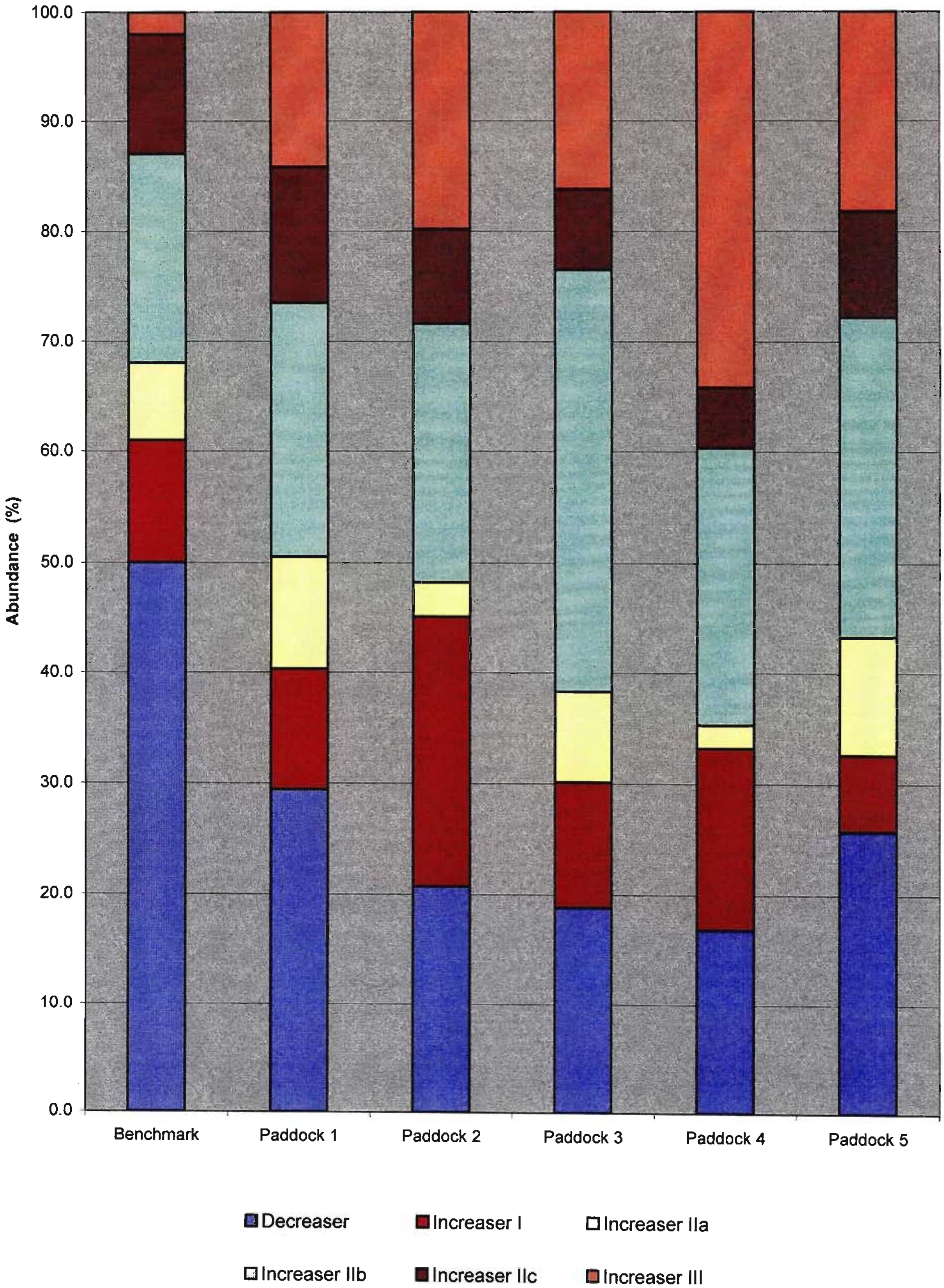

Figure 2.5 Relative abundance of veld species compared to a benchmark.

2.3.2.2 Correspondence Analysis

A Correspondence Analysis (CA) was conducted on the veld condition data (Ter Braak 1987) and included both species and paddocks as variables (see Appendix 3 on page 106). The aim of this analysis was to clarify the trends noted in the carrying capacity assessment. The first four axes accounted for 63.6% of the variance in the species distribution, with Axis 1 and Axis 2 accounting for 31.1% and 14.2% of the species variance, respectively (Table 2.1).

Table 2.1 Eigenvalues for Correspondence Analysis of veld paddocks and grass species

Axes	1	2	3	4	Total Inertia
Eigenvalues	0.135	0.062	0.046	0.034	0.434
Cumulative percentage variance	31.1	45.3	55.8	63.6	
Sum of all uncontrolled Eigenvalues					0.434

The combined CA of paddocks and species (see Figure 2.6 overleaf) showed that paddocks 1, 3 and 5 were characterised by species such as *Eragrostis curvula*, *Themeda triandra* and *Tristachya leucothrix* and Paddocks 2 and 4 by species such as *Cymbopogon excavatus*, *Hyparrhenia hirta* and *Aristida junciformis*. Combining these findings with the grazing class data, it is clear that the principal factor influencing the distribution of species was grazing. An analysis of species distribution and growth characteristics (Figure 2.6 overleaf) showed that Axis 1 tended to separate Decreaser and Increaser III species, suggesting a grazing frequency gradient. Axis 2 separated Decreaser and Increaser IIb species and suggests a grazing intensity gradient.

2.3.2.3 Kikuyu weed encroachment

Kikuyu is conventionally established as a mono-specific sward, and so any additional species detected can be regarded as weeds (Bromilow 1995). These weed species tend to encroach in pastures that are poorly utilised; and decrease the overall quality of the grazing. Many weed species are avoided by grazing animals and thus increase in abundance.

The Kikuyu HSR pasture had a purity of 87.8%, indicating that 12.2% of the pasture was taken up by undesirable plant species. The most prolific invader species was *Cynodon dactylon* (4.6%), followed by *Sporobolus africanus* (see Table 2.2).

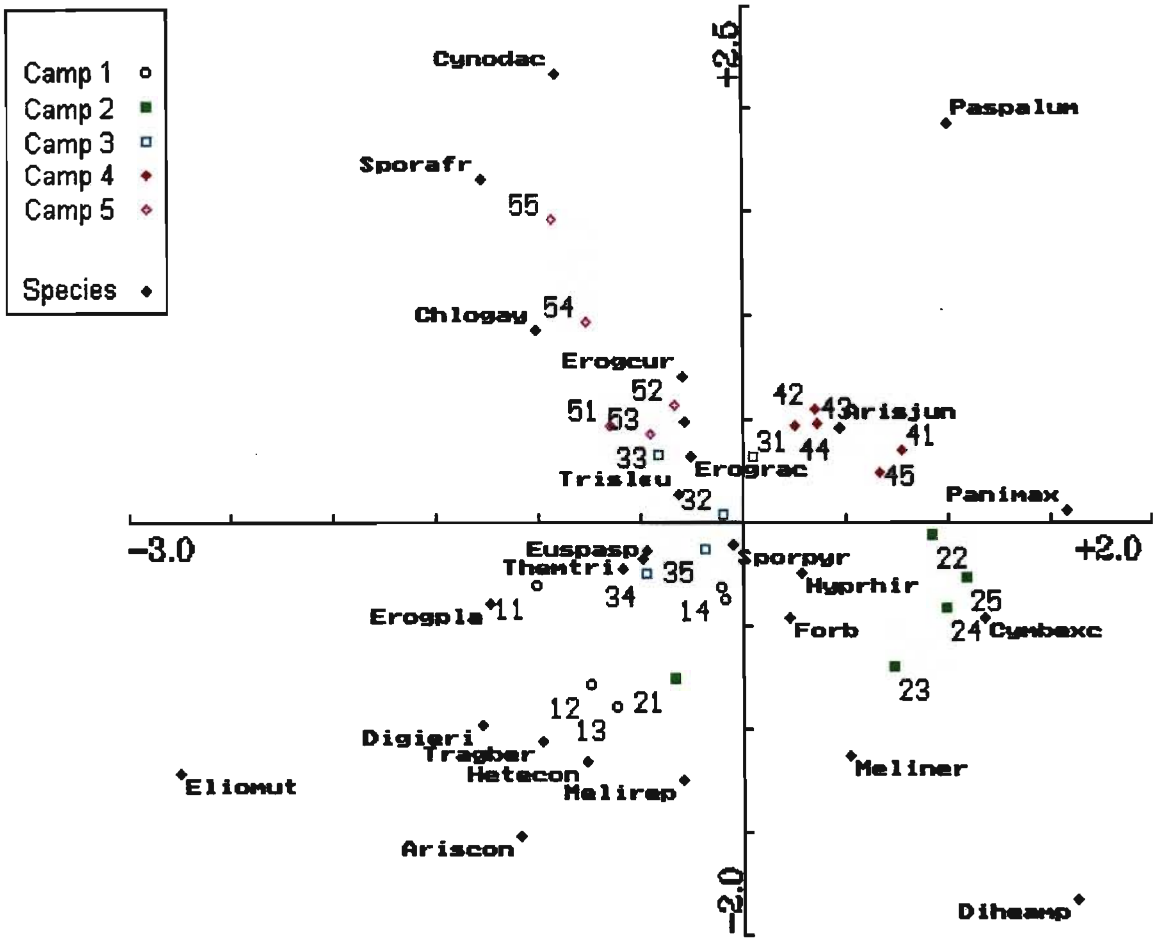

Figure 2.6 Correspondence analysis of species and veld paddocks.

The Kikuyu LSR pasture was less pure (only 76.8%), with *Eragrostis curvula* the next most common species, comprising 16.4% of the sward. Although not a distinct problem during the trial, this encroachment will need to be addressed before animal production from these pastures can be improved.

Table 2.2 The percentage of different grass species found in the two kikuyu pastures

Species	Kikuyu HSR	Kikuyu LSR
Pennisetum clandestinum	87.8	76.8
Eragrostis curvula	1.0	16.4
Cynodon dactylon	4.6	0.4
Sporobolus africanus	3.0	1.2
Paspalum notatum	2.6	0
Forbs	1.0	2.4
Panicum maximum	0	2.4
Digitaria eriantha	0	0.4

2.3.3 Available herbage

2.3.3.1 Calibration

To ensure accuracy, the disc meter was calibrated for both the veld and kikuyu pastures using the technique discussed by Bransby (1975). The linear regression equation to predict forage yield (kg ha^{-1}) (Y) from disc metre height in cm (X)

for the veld was $\mathbf{Y = 160.46\ X + 363.52}$ (R^2= 55.6%);

and for kikuyu was $\mathbf{Y = 335.11\ X - 242.2}$ (r^2= 82.9%).

These equations were plotted (Figure 2.7 overleaf) to show the differences in potential fodder production from the veld and kikuyu treatments.

For kikuyu, the regression matched the data well, with a linear regression achieving an R^2 value of 83% from 200 samples. The veld regression only achieved an R^2 of 56%, but because of the diversity of species, this value was considered adequate for providing an index of standing crop.

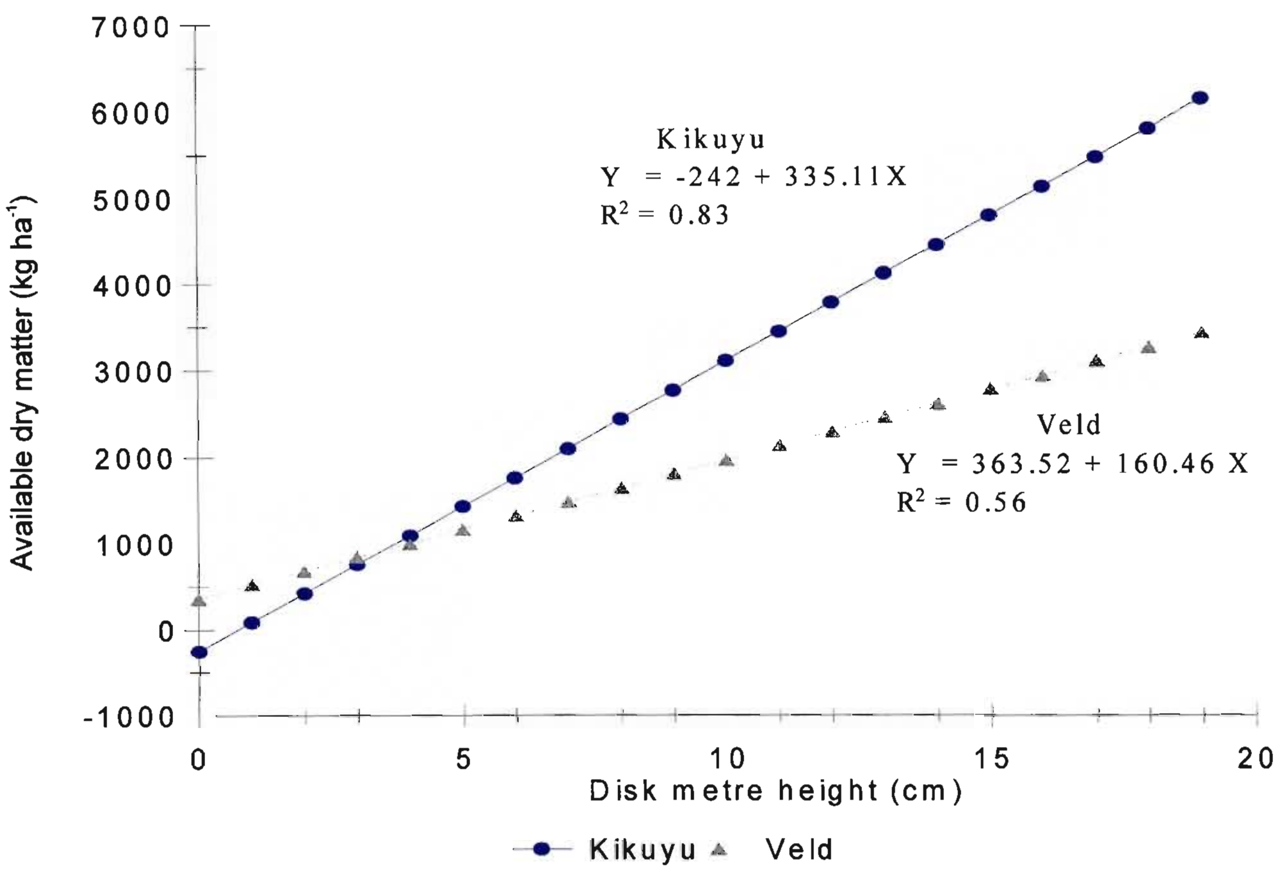

Figure 2.7 Calibration regressions for a falling plate disc meter on Veld and Kikuyu recorded at Ukulinga Research Farm

2.3.3.2 Seasonal available herbage

Herbage height was measured using a falling plate disc meter to quantify the amount of fodder available at each sampling date (on a kg ha^{-1} basis).

No statistically significant differences in available herbage were detected ($P>0.05$) between paddocks in each grazing treatment (veld, Kikuyu HSR & Kikuyu LSR). This meant that the data could be pooled per date.

Rainfall and temperature (Figures 2.2 & 2.3; page 25) have a substantial effect on herbage growth. As growth factors, their effects are complementary, and extremes of either of these factors have the potential to limit growth.

The loss of herbage through grazing is a constant pressure in continuously grazed systems, and increases as the effective stocking rate increases with animal growth. The rate of consumption is influenced by both environmental and biological factors. It is beyond the scope of this trial to quantify these effects. The data used to calculate available herbage are presented in Appendix 4 on page107.

2.3.3.2.1 Veld

There was very little fluctuation in the amount of standing herbage during Season 1 (see Figure 2.8; page overleaf). Available herbage increased consistently from about 1226 kg ha^{-1} until midsummer (December). Poor rainfall limited herbage production during December, but this improved once the rain returned in early January. Improving climatic conditions led to the amount of herbage available for grazing increasing consistently until the end of the season (over 2000 kg ha^{-1} by February). Over the season there was an average of 600 kg DM ha^{-1} available for consumption.

Available veld grazing increased gradually from about 1308 kg ha^{-1} throughout Season 2 (Figure 2.9; page overleaf). As with Season 1, a nominal decline in standing crop was noted during midsummer, although the fall was not as severe as in Season 1. Although rainfall decreased substantially during the latter periods of Season 2, this had no apparent influence on available grazing. Averaged over the season, available forage per hectare increased by 100 kg, to 1700 kg DM ha^{-1}, compared to Season 1.

2.3.3.2.2 Kikuyu

For most of Season 1 (Figure 2.8 overleaf) the standing crop (as determined using the disc pasture meter (Bransby 1975) from both kikuyu pastures was similar. Although the

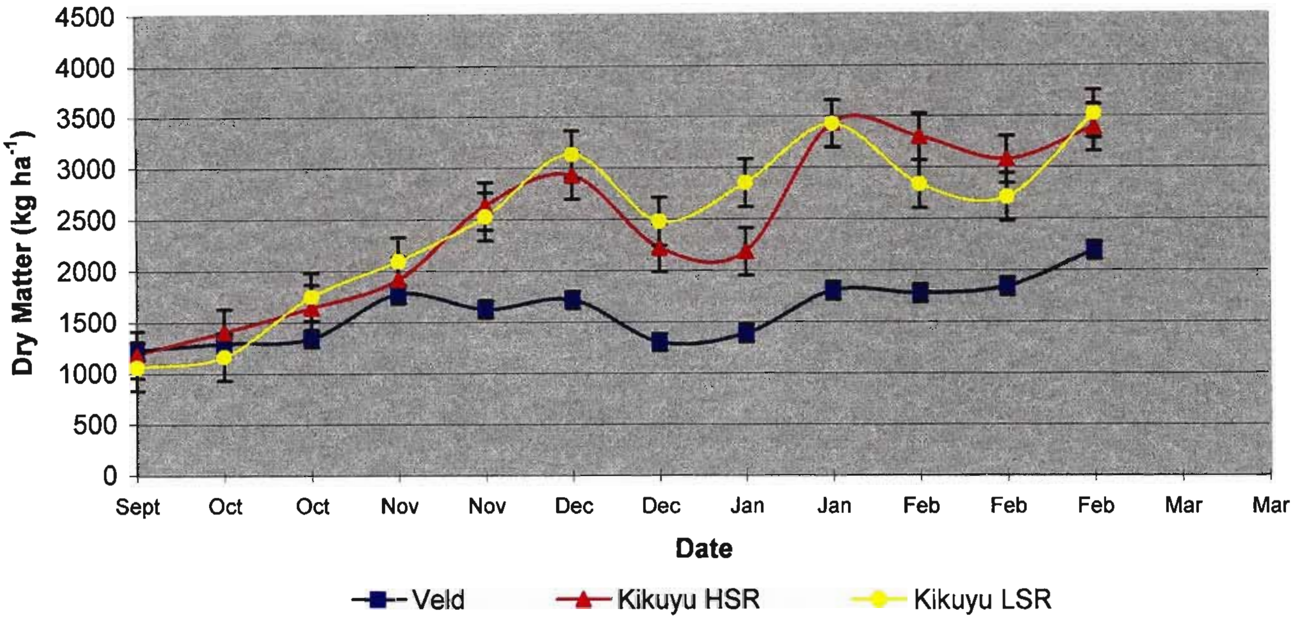

Figure 2.8 Herbage on offer for Veld and Kikuyu (HSR & LSR) in Season 1.

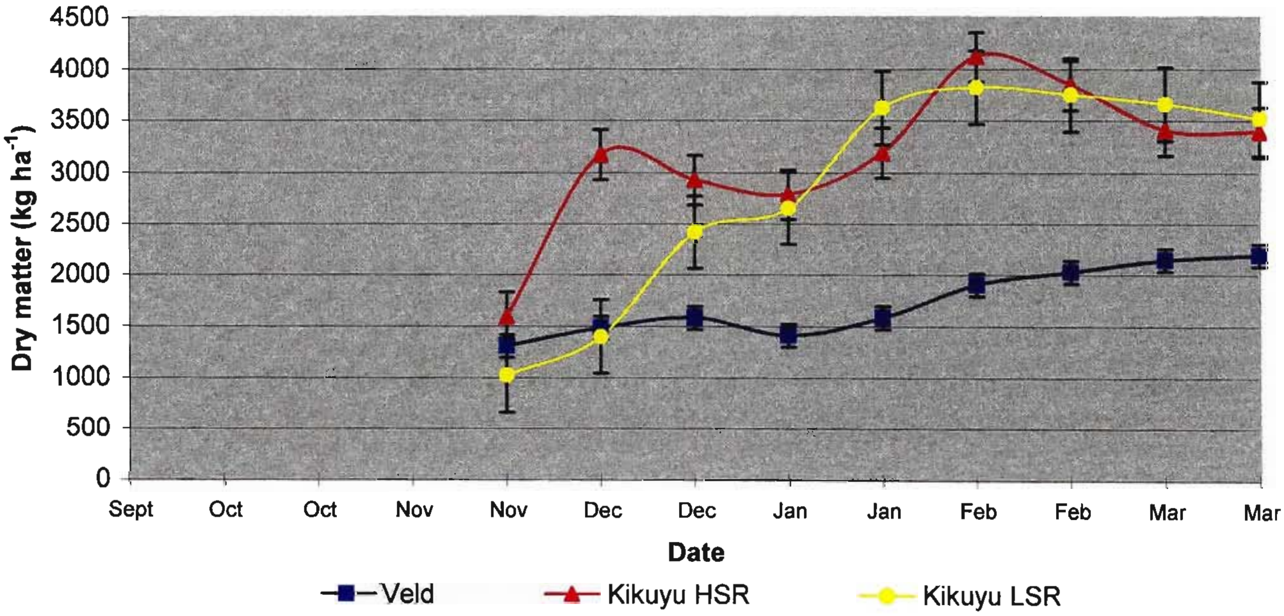

Figure 2.9 Herbage on offer for Veld and Kikuyu (HSR & LSR) in Season 2.

pastures required about a month to begin growth, both accumulated herbage at approximately the same rate. As with the veld, the midsummer drought slowed these growth rates substantially. Rain during January rapidly increased available herbage, but this again declined towards the end of the season. Two issues of importance for kikuyu pasture management were noted. Firstly, kikuyu pastures are very reliant on a constant supply of water (as noted during the midsummer drought), but the rate of recovery was also rapid (as noted in January). Secondly, low stocking rates tended to buffer against poor growth, but limited the rate of recovery when climatic conditions improved.

At the beginning of Season 2, the Kikuyu HSR pasture had a significantly faster ($P \leq 0.05$) growth rate compared to Kikuyu LSR, though within one month both pasture growth rates had stabilized with approximately the same level of available herbage (Figure 2.9 page 34). The shallower soils of the Kikuyu LSR pasture may have been drier and thus initially restricted growth. Available herbage increased at a consistent rate for most of the remainder of the season, only declining during March when climatic conditions restricted growth. Although the rainfall in Season 2 was limited and the average temperature was higher, on average 550 kg more herbage was available compared to Season 1 (2450 kg DM ha^{-1} versus 3000 kg DM ha^{-1}).

2.3.4 Laboratory analyses

Chemical analyses provide a repeatable method of investigating internal plant characteristics. Forage digestibility was determined using an *in-vitro* procedure known as the Cellulase technique (Zacharias 1986). Nitrogen content was determined using Kjeldhal analysis (Brenton-Jones 1991) and was converted to crude protein percentage.

Apart from quantifying the nutritive characteristics of the three fodder treatments, chemical analyses were used to determine if significant nutritional differences existed within the five veld paddocks (as suggested by veld condition assessments).

A comparison of the data from each veld paddock using t-tests (Steele & Torrie 1980) indicated that there were no statistically significant differences in nutrient status, confirming that cattle selectively grazed in each veld paddock. Cattle production was, therefore, unlikely to have been adversely affected by the varied species composition in each paddock. This finding is important because it allows the analyses from individual paddocks to be pooled to give average figures for the veld.

The same principal held for the two kikuyu pasture treatments, where uniform quality allowed the data to be pooled, increasing the treatment data set for statistical analysis.

2.3.4.1 **Digestibility**

Digestibility is a measure of the quality of fodder and it reflects the degree to which plant material is broken down by dietary enzymes. The greater the amount of material digested (higher digestibility %), the higher is the quality of the herbage. The raw data used for digestibility analyses are presented in Appendix 5 on page 109

2.3.4.1.1 **Veld**

The digestibility of the veld peaked very early in Season 1 (see Figure 2.10 overleaf) at about 51%, steadily declining throughout the remainder of the season to end at below 40%. Of interest was the rapid decline in digestibility with the midsummer drought. The decline was probably due to a combination of lower plant growth rates and a greater proportion of mature plant material in grab samples taken at that time.

The digestibility of the veld was again high (60%) at the beginning of Season 2 and declined consistently throughout the season (see Figure 2.11 overleaf). The high digestibility at the beginning of the season was unexpected because limited rainfall had been received before grazing commenced. The high digestibility percentages at the beginning of the seasons indicate that veld grasses are well adapted to utilising early spring rainfall. The decline in the digestibility of available herbage throughout each season can be attributed to both the accumulation of moribund material and the onset of reproductive growth in the veld grasses, as well as a normal increase in structural material through lignification.

2.3.4.1.2 **Kikuyu**

The initial digestibility of the kikuyu from both grazing treatments in Season 1 was poor (below 50%), but digestibility increased consistently, peaking during midsummer (near 60%) after which it declined significantly due to a lack of rainfall (Figure 2.10 overleaf). The onset of rain in January improved digestibility nominally before a significant decline during February and March. For a substantial portion of the season there were no significant differences ($P>0.05$) in digestibility for either grazing treatment. The nominal difference in digestibility during the midsummer drought was attributed to higher grazing pressure on the Kikuyu HSR treatment. These cattle would have consumed herbage at a faster rate, accessing mature or moribund material sooner than the lighter stocked treatment. At the onset of the Season 2, the digestibility of the two kikuyu treatments was very similar (48 –

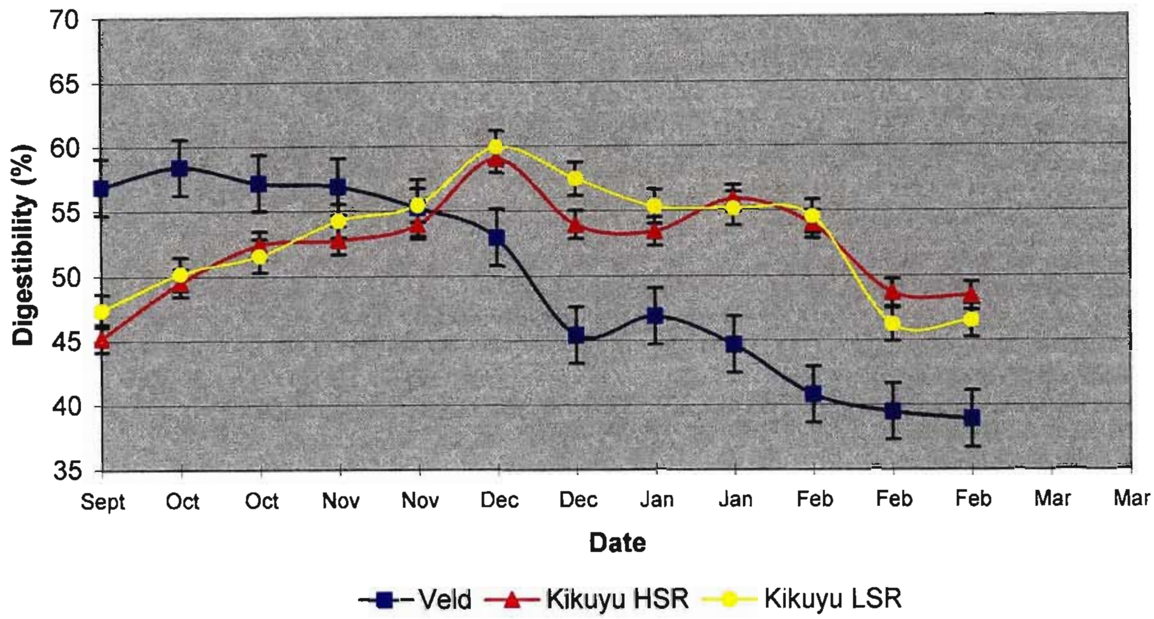

Figure 2.10 Digestibility of Veld and Kikuyu (HSR & LSR) in Season 1.

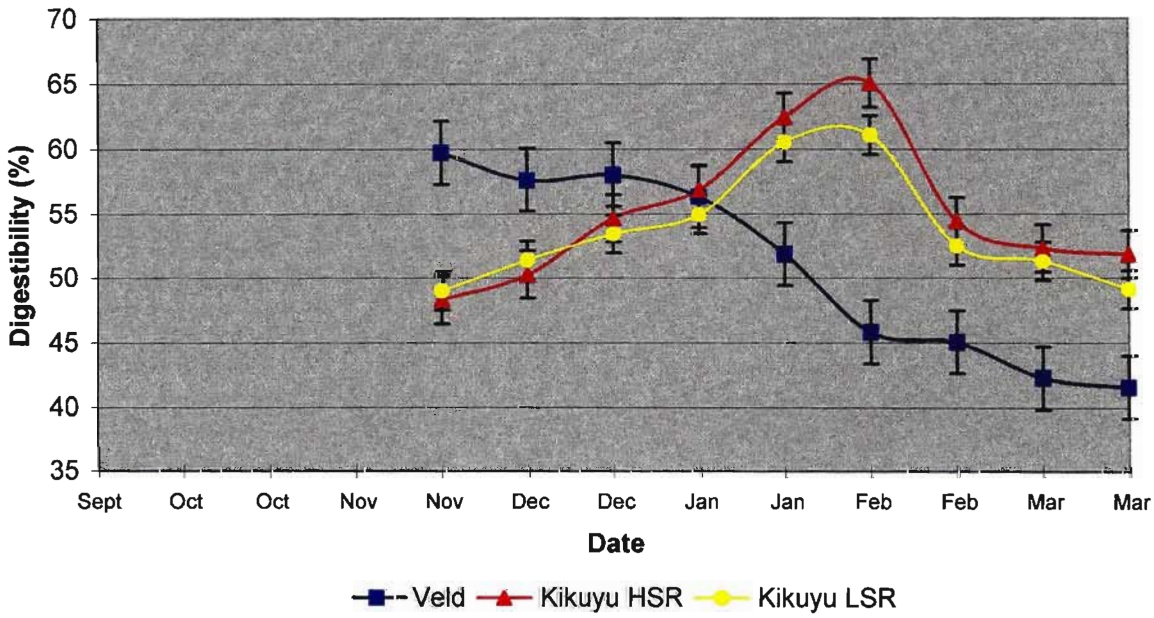

Figure 2.11 Digestibility of Veld and Kikuyu (HSR & LSR) in Season 2.

49%), increasing to over 60% consistently in early February (Figure 2.11 previous page). The digestibility percentage of the available herbage then declined rapidly to the end of the season. The later onset of grazing appeared to favour the Kikuyu HSR treatment with a statistically significant higher (P>0.05) peak digestibility recorded. As Season 2 did not experience any significant midsummer drought, the rapid decline in digestibility at the end of the season was attributed to the dilution of quality material with unutilized material.

These data show that grazing pressure plays an important role in determining the digestibility of kikuyu. Although insufficient rainfall limits pasture growth in poor seasons, with adequate moisture the constant utilization of herbage helps to improve digestibility (and hence fodder quality).

2.3.4.2 **Crude protein**

Protein is one of the most important nutrients required for live mass production. It is important to have an accurate impression of the amount of crude protein contributed by the grazing to ensure that dietary requirements are always met.

Analyzing for nitrogen provides a robust method of indexing crude protein values, as these data can easily be converted to crude protein percent using a standard conversion factor. For raw data see Appendix 6, page111.

2.3.4.2.1 **Veld**

At the beginning of the Season 1 (see Figure 2.12 overleaf), the crude protein percentage (5%) was low, and rose slowly until December when it peaked at about 11%. The crude protein levels then fell consistently. Crude protein tended to peak at times of moisture stress (midsummer and end of season), though the reason for this trend not clear.

Season 2 (see Figure 2.13 overleaf) displayed far less fluctuation, with the crude protein percentage gradually rising to a peak of about 9% in mid-January, and then declining steadily to the end of the season. Although Season 2 had a more constant accumulation through the season, the average crude protein levels in the two seasons were very similar, suggesting that crude protein percentage on veld is not as dependent on rainfall as some of the other growth factors measured.

2.3.4.2.2 **Kikuyu**

Unlike many of the other variables measured, crude protein percentage varied substantially between the two kikuyu pasture treatments. At the beginning of Season 1

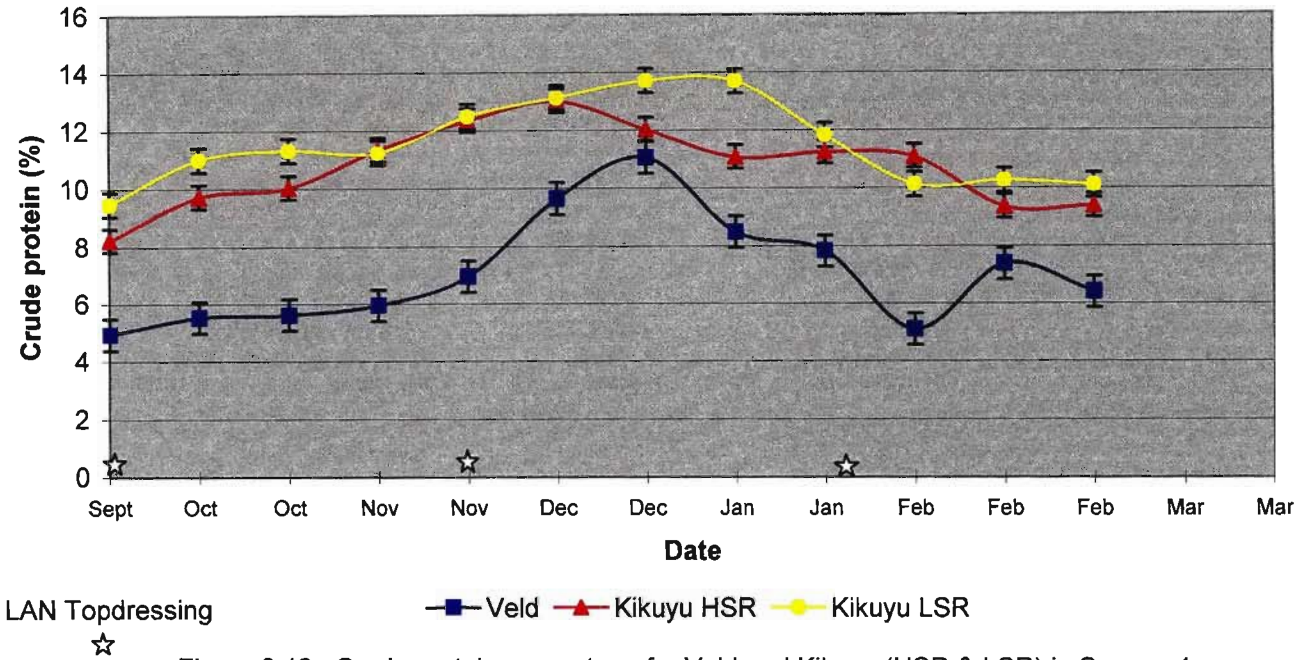

Figure 2.12 Crude protein percentage for Veld and Kikuyu (HSR & LSR) in Season 1.

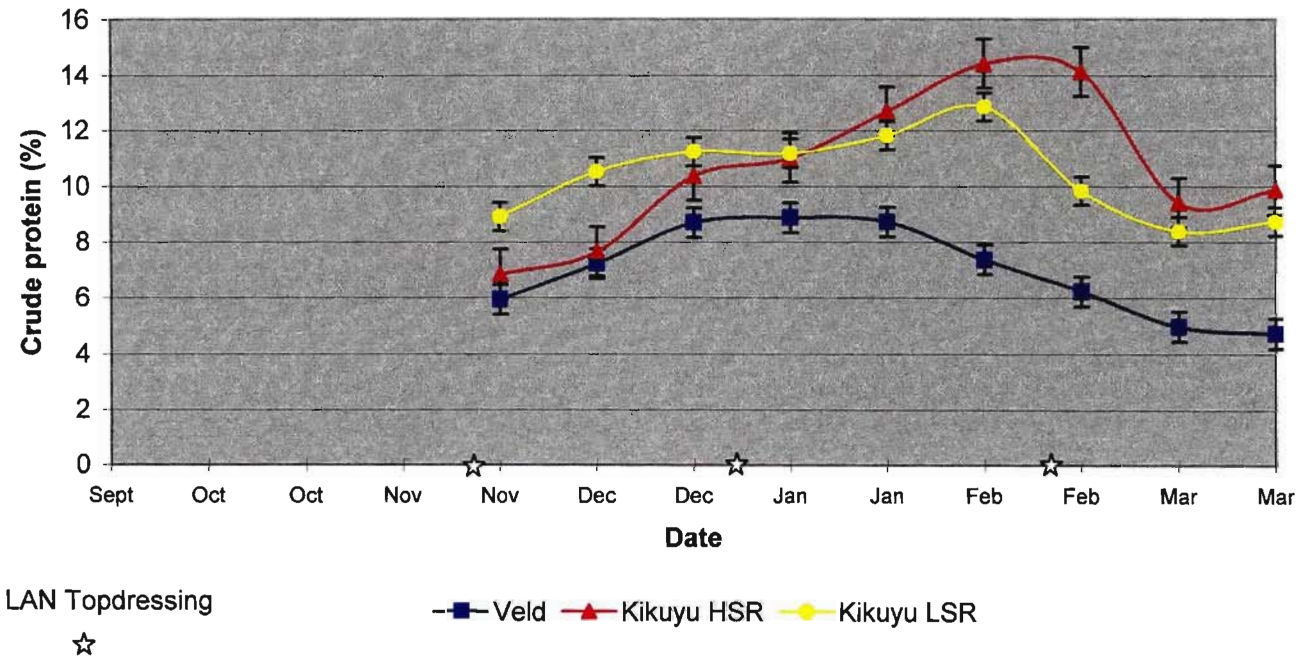

Figure 2.13 Crude protein percentage for Veld and Kikuyu (HSR & LSR) in Season 2.

(Figure 2.12 previous page) the kikuyu LSR pastures had a significantly higher ($P \leq 0.05$) crude protein value than the Kikuyu HSR pasture (9% versus 7%). As the season progressed, these differences decreased until midsummer, when the crude protein percentage of the Kikuyu HSR pasture dropped significantly. Crude protein percentages declined for both pastures in late summer, with no apparently statistically significant differences.

Apart from commencing later, Season 2 (see Figure 2.13 page 39) had more normal weather conditions, and far less difference in crude protein was noted between the pastures. The typical crude protein distribution curve was noted; with levels increasing until midsummer and then declining. The Kikuyu HSR treatment had statistically significantly higher ($P \leq 0.05$) levels of crude protein in the latter part of the season (for example 14% versus 10% in late February) possibly due to higher levels of dung and urine.

The topdressing of the pastures with LAN had very little long term effect.

2.4 Discussion

A clear understanding of the quality and quantity of fodder during a season, and the reasons for these trends, provide a solid base from which to examine the subsequent trial data. Fodder trial data must be reviewed holistically to understand the limitations and potential of each production system.

2.4.1 Veld

Veld comprises the mixture of naturally occurring grass species that occupy an area. Veld management focuses on changing or maintaining a blend of species that will sustainably maintain animal live mass gain. Each species has a unique blend of quality and quantity characteristics that determine its production potential. The cumulative representation of these is known as the carrying capacity.

Veld Condition

Veld condition represents a baseline from which animal production can be anticipated; and it is calculated by surveying species composition. The trial data were analysed to address two key questions: What was the carrying capacity of the veld, and are there any statistically significant differences between paddocks that could negatively influence animal performance?

Analysis of the species composition data (Camp 1999) showed that the veld condition was fair to good (50-70% of the benchmark). Each paddock was considered sufficiently productive to carry the number of animals required for the trial.

Regarding paddock uniformity, analyses (VCA and CA) indicated that differences exist between the paddocks with respect to carrying capacity and species composition. To determine the cause of these differences, paddocks were compared with respect to their similarities and differences in species composition. The differences in species composition were due to grazing pressure, suggesting that at some previous time the paddocks had been used for a stocking rate trial (though records to verify this were unavailable). Differences in stocking rate would have altered species composition, with heavily-grazed paddocks containing higher proportions of Increaser II species, and lighter-grazed paddocks having more Increaser I and III species, as noted in the veld condition analyses.

Overall Assessment

All the data collected for the veld treatment are combined in Figure 2.14 (overleaf) to compare the data from both seasons on a standardised basis. Although climate played an important role in defining production for both seasons, the basic production curves (for the measured factors) appear very similar.

Season 1 began with low levels of fodder with a high digestibility and low crude protein content. As the season advanced, adequate rainfall ensured an increase in both available fodder and crude protein percentages, whilst digestibility declined. The decline in digestibility has been attributed to a decrease in the proportion of young to mature leaves in each sample. As rainfall declined during mid December, total available dry matter, crude protein percentage and digestibility percentage declined (as plant growth slowed). The onset of rain in January produced new forage growth, which increased both available biomass and the digestibility percentage of the grazing. Crude protein levels, however, declined. The onset of reproductive growth in many veld species during the latter stages of the season caused a decrease in both crude protein and digestibility percentage, whilst available dry matter levels continued to improve.

Very similar trends were noted for veld in the Season 2, although grazing only commenced during November because of a lack of rain. The absence of a major midsummer drought ensured that the rate of forage production remained high throughout the season, with no unanticipated declines in production.

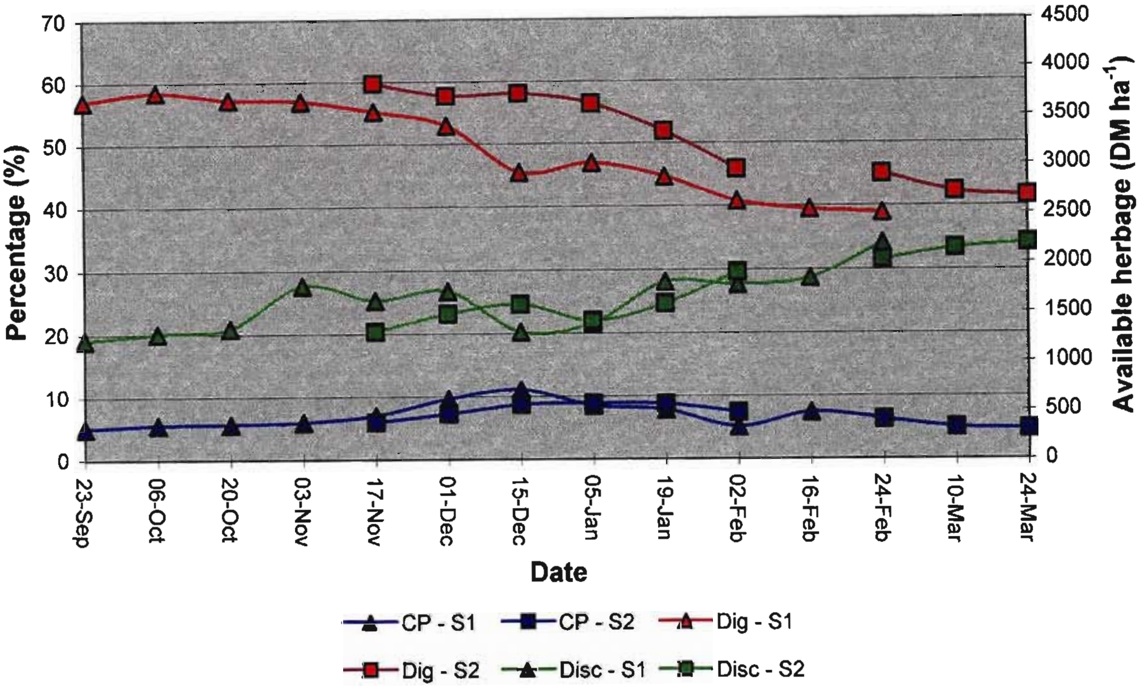

Figure 2.14 Combined veld vegetation analyses for Season 1 and 2.

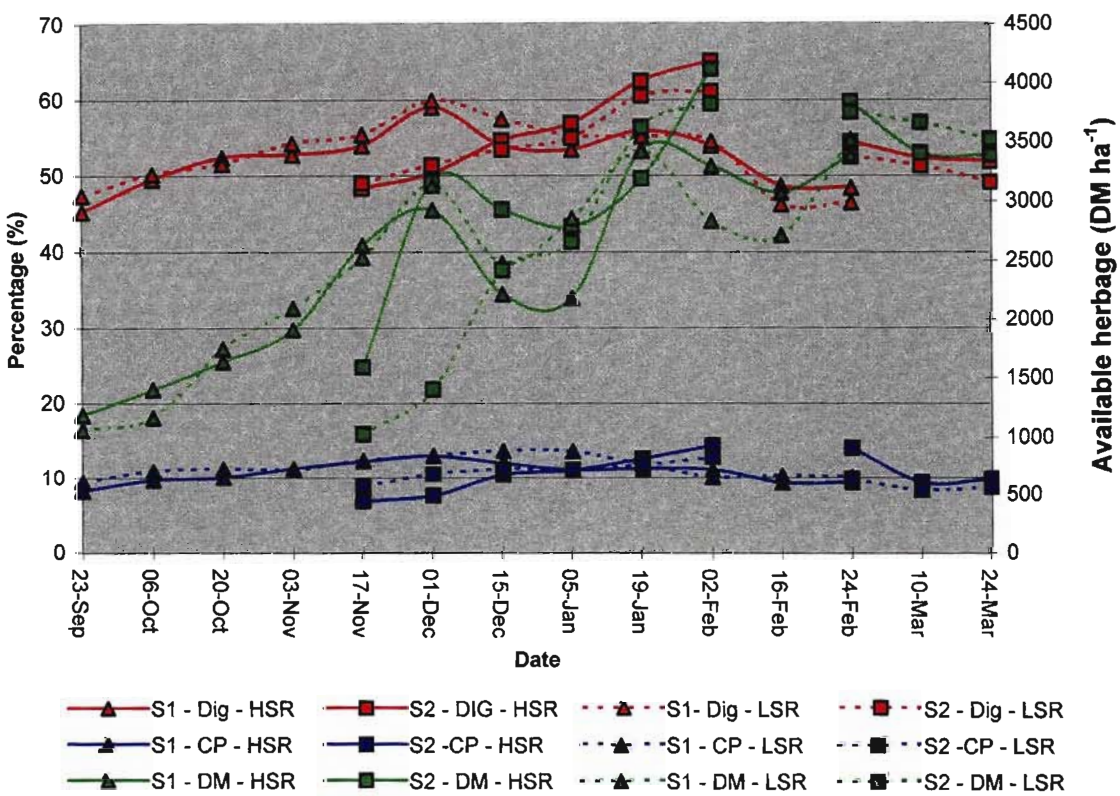

Figure 2.15 Combined Kikuyu (HSR & LSR) vegetation analyses for Season 1 and 2.

The delay in the commencement of grazing apparently had little effect on the levels of available biomass and crude protein (following similar timings in both seasons). This suggests that these factors are closely associated with seasonal factors such as day length. The decline in digestibility (although at the same rate) was offset by almost a month in the second season, suggesting it was influenced by environmental rather that seasonal factors.

2.4.2 **Kikuyu**

Pasture growth is influenced by both past and current management strategies. Past management practices influence long-term productivity, whilst current management practices influence short-term pasture productivity.

Botanical composition and condition

Optimum production is achieved when pastures are maintained true to their original species composition (Humphreys 1994), with production decreasing in more heavily invaded pastures. Although both kikuyu pasture treatments were moderately (10-20%) invaded by alien species, this degree of invasion did not limit animal live mass gain. Although not measured, it is acknowledged that if stock had actively avoided a particular invader species, stocking rate would have inadvertently been increased, potentially limiting live mass gain.

Historically, both kikuyu pastures were burnt annually during winter and grazed in summer (du Toit pers. comm. 1999). These regular interventions apparently had not diminished the production potential, the available herbage (2.5-3.0 t DM ha^{-1} per sampling date) and average digestibility of 53-54%, were similar to the levels found by Bransby on the same pastures 20 years previously (Bransby 1983).

Overall assessment

Kikuyu is an ideal pasture species, with the potential to produce large amounts of good quality forage throughout summer, but it is vulnerable to moisture stress. Kikuyu is also very tolerant of high stocking rates, but requires careful management to optimise both the quality and quantity of herbage produced.

All of the data collected for the Kikuyu HSR and LSR treatments are combined into a single figure to aid in comparisons (see Figure 2.15 page 42).

In Season 1, climate was the principal factor influencing herbage production for both kikuyu grazing treatments. For most of the season, both treatments were statistically similar for the three production variables. Kikuyu's high requirement for moisture was evident during the mid summer drought when production declined on both pastures. The lighter stocking rate appeared to buffer the pasture against the drought, with more available herbage of a higher quality than the Kikuyu HSR treatment. Improved rainfall later in the season generated a degree of compensatory growth before the anticipated end of season decline in quality as winter approached.

In Season 2, herbage quality followed similar patterns to Season 1, but without the midsummer decline in growth. Both crude protein content and digestibility increased to a peak during midsummer, before declining at the end of the season due to the onset of reproductive growth and the dilution of the herbage sample with moribund material. The improved climatic conditions in Season 2 ensured that, on average, the quality of the herbage was better, and herbage was more abundant.

Comparing the two seasons, both available herbage and crude protein percentage tended to follow the same trends, despite a delay in the commencement of Season 2 by approximately 30 days due to delayed rainfall.

2.5 **Conclusions**

The trial variable with the greatest effect on productivity was rainfall. A midsummer drought in the Season 1 decreased herbage production and quality during the latter stages of that season, whilst late rain in Season 2 reduced the time available for production.

If it is reasonable to assume that the veld in this trial is representative of that found locally then it is apparent why summer beef production from veld is so popular. Trial data show only a minor deterioration in veld quality during times of water stress, implying that veld can be relied on to provide a moderate quality source of grazing on a consistent basis. Although limited in terms of total biomass production, the extensive nature of veld grazing systems ensure that as long as stocking rates are accurately evaluated and maintained, these systems are suited to summer beef production. Veld production systems would also be highly suited to supplemental feeding systems, as the nutritional profile of the fodder is consistently predictable and, hence, deficiencies can easily be managed.

By contrast, kikuyu pastures provide an abundant source of high quality grazing material. The production of this dry matter is highly dependant on moisture and can be limited during times of moisture stress. As long as moisture is not limiting, the high quality fodder from kikuyu pastures offers a reliable method of improving production per hectare. To optimise live mass production, the use of the pasture must be optimised so that a balance between pasture growth and animal live mass gain is achieved.

If correctly managed, both sources of grazing can be used to sustainably produce beef during summer. Before selecting a source of grazing, many additional factors such as required animal production and potential economic return need to be considered to ensure that the production system selected is both biologically and financially sustainable.

Chapter 3 analyses how summer beef production on the trial veld and kikuyu treatments was affected by supplementation.

CHAPTER 3

ANALYSIS OF SUMMER SUPPLEMENTED CATTLE PRODUCTION ON THE TRIAL VELD AND KIKUYU PASTURES

3.1 Introduction

Animal production gains from summer grazing are often erratic, with live mass gains influenced by forage quality and quantity, animal type and climate. To try and promote more consistent production, supplementary feeds can be supplied to address nutritional deficiencies. Supplementation seeks to optimise production by balancing animal requirements and nutritional supply with available grazing, with the level of supplementation depending on the quality of the grazing.

The study addressed several issues important to beef production including:

- the differences in live mass production of cattle grazing veld or kikuyu;
- the influence of stocking rate (on kikuyu pastures) on live mass production;
- the links between animal production and supplements with differing protein and energy characteristics;
- the effects of hormonal growth enhancing agents, and
- the influence of animal sex on live mass production.

3.2 Procedure

A summer beef production trial was located at Ukulinga Research and Training Farm (Pietermaritzburg) on veld and kikuyu pastures (as described in Chapter 2) to examine how four supplementary feeds (of differing protein and energy characters) affected the efficiency of beef production - measured live mass gain and carcass quality.

3.2.1 Grazing

The trial was conducted over Season 1 and Season 2 on the veld paddocks and Kikuyu HSR and Kikuyu LSR paddocks described in Chapter 2.

The veld measured 35.0 hectares (ha) and was divided into five paddocks of equal area. At the beginning of each season, the veld was stocked at a rate of 0.18 AU ha^{-1}, which constituted 25 weaners (avg. mass 214.1 kg), distributed between the five paddocks.

The Kikuyu HSR pasture measured 3.8 ha and was divided into 10 paddocks. The Kikuyu HSR pasture was stocked at 1.92 AU ha^{-1} and constituted 30 weaners (avg. mass

213.0 kg) between 10 paddocks. The Kikuyu LSR pasture measured 3.2 ha and was divided into four paddocks. This treatment was stocked at half the rate of the Kikuyu HSR treatment (0.89 AU ha^{-1}) and constituted 8 weaners (avg. mass 226.1 kg) distributed over four paddocks.

If cattle were removed from a treatment due to illness or disease, they (or a suitable replacement) were returned to the relevant treatment as soon as possible, to ensure a consistent grazing pressure for each grazing treatment.

A basic analysis (Table 3.1) of the quality of the grazing resources showed that the quality (digestibility and crude protein) and quantity of herbage from the veld was significantly lower ($P \leq 0.05$) than that from kikuyu. No significant differences in quality or quantity of herbage produced were found between the Kikuyu HSR and Kikuyu LSR grazing treatments.

Table 3.1 Basic qualities of the gazing material averaged over Season 1 and Season 2

Item	Veld	Kikuyu HSR	Kikuyu LSR
Average digestibility (%)	50.7	53.8	53.5
Crude Protein (%)	7.06	11.3	11.59
Available dry matter (kg ha^{-1})	1663	2747	2639

3.2.2 Supplements

For simplicity, the supplemental rations were identified by their distinguishing characteristic or ingredient as follows:

a) Grass - No supplement provided (Grazing only);

b) Standard - Commercially available molasses-based Protein/Energy/Mineral ration;

c) Natural Protein - Standard ration with alternate protein source (Dried Brewers Grains);

d) Avoparcin - Natural Protein ration with energy enhancing additive (Avoparcin); and

e) Bentonite - Natural Protein ration with protein enhancing additive (Bentonite).

The dietary effects of these additives were discussed in Chapter 1.

3.2.2.1 Supplement analyses

The chemical analyses of the four feed supplements (Table 3.2) revealed no biologically significant differences in ration composition. Energy content was not analysed due to financial limitations.

Table 3.2 Biochemical analysis of feed supplements

Rations	Crude Protein (%)	Ca (ml l^{-1})	K (ml l^{-1})	Na (ml l^{-1})	K/CA + Mg (ml l^{-1})	P (ml l^{-1})
Standard	17.07	0.62	2.99	4.89	1.18	0.52
Natural Protein	16.94	0.80	2.92	5.52	1.01	0.72
Avoparcin	16.23	0.93	3.05	5.16	0.95	0.79
Bentonite	15.97	0.81	2.86	5.29	0.93	0.71

3.2.2.2 Dietary crude protein

The total crude protein (CP) in each diet was calculated on an individual treatment basis (Table 3.3) by averaging the CP of the grazing source (as found in Chapter 2) and adding the ration CP. These values provide an indication of total treatment CP.

Table 3.3 Total treatment crude protein values averaged over Season 1 and Season 2

		Grass	Standard	Natural Protein	Avoparcin	Bentonite
Veld	Grazing	7.05	7.05	7.05	7.05	7.05
	Supplement	-	17.07	16.94	16.23	15.97
	Total	**7.05**	**24.12**	**23.99**	**23.28**	**23.02**
Kikuyu HSR	Grazing	11.25	11.25	11.25	11.25	11.25
	Supplement	-	17.07	16.94	16.23	15.97
	Total	**11.25**	**28.32**	**28.19**	**27.48**	**27.22**
Kikuyu LSR	Grazing	11.48	11.48	11.48	11.48	11.48
	Supplement	-	17.07	16.94	16.23	15.97
	Total	**11.48**	**28.55**	**28.42**	**27.71**	**27.45**

For the un-supplemented treatments, average dietary CP tended to be below that recommended by Gertenbach (1998), especially when it is considered that not all CP is available for digestion. Supplementation improved dietary crude protein by 16.5%.

3.2.3 Cattle

In both seasons, 65 crossbred (*Bos indicus*) weaners of both sexes, in good condition and with an average mass of 215 kg ±29.23 kg were purchased. Each weaner was assigned to one of the five feeding treatments, with all cattle being slaughtered at the end of each season, and half of the animals in each group were implanted with the Revalor Plus® growth promoter. Pre-trial management practices (including dipping, dosing for internal pests and castration) were identical for all animals.

Cattle were randomly allocated supplemental rations using the procedures defined by Steel & Torrie (1980), ensuring an equal balance of male and females for each ration and grazing source. All supplements were fed at a rate of 1.4 kg animal day^{-1} on a daily basis throughout the trial (as per the feed manufacturer's recommendations).

3.2.4 Season completion

The end of the season was determined by one of three factors, namely:

a. when the average daily gain (ADG) declined for three consecutive weeks for at least 50% of the cattle;

b. when more than 70% of the cattle achieved a condition score of 3; or

c. when the quantity or quality of forage available was insufficient for productive growth.

With respect to meeting these targets, it was not possible to meet either the first or second criteria as in both seasons the trial was closed due to a lack of grazing. Cattle were thus sent to the abattoir in poor condition which is reflected in the analysis of supplement efficiency and economic productivity.

3.2.5 Measurements

A variety of measurements were collected to assess animal performance, including weekly mass, abattoir data and samples for laboratory analysis.

3.2.5.1 Weekly weighing

Cattle were weighed weekly for the duration of both seasons, and the results are presented as average daily gain (ADG) and live mass gain per season in Appendix 7 (page113) and Appendix 8 (page 114).

Three measures of performance are available for comparing production data; total live mass gain; ADG; and production per hectare. Due to the differing lengths of the seasons, ADG was selected as the best method for evaluating performance, as it does not use time as a determining variable.

3.2.5.2 Abattoir analyses

At the end of each season all cattle were slaughtered and the following data collected:

- slaughter mass (kg);
- dressing percentage (%);
- fat cover score (0-5); and
- condition score (0-5).

These data were collected to evaluate if the feed supplements had any influence on the finished condition of the cattle, and to establish the effects of these supplements on carcass condition and value.

3.2.6 Statistical analyses

Data were presented in terms of live mass gain per hectare and ADG. Interpreting these data on a per hectare basis is important because production needs to be assessed relative to that resource with the greatest capital investment (to ensure optimisation of returns). The ADG provides a method for comparing data that differ with respect to time, as time is standardised. This was important for this trial because Season 2 was 33 days shorter than Season 1.

Overall production was averaged over both seasons and analysed using t-tests and analysis of variance tables to establish if significant differences ($P \leq 0.05$) occurred between treatments.

In some situations data were excluded because they introduced an excessive bias in treatment responses. Data were excluded only where a difference in live mass gain of over 50 kg (compared to the treatment average) was established. In such situations, the uncorrected average live masses are noted together with the corrected value used for further discussion.

The most important conclusion from the statistical analyses was the lack of statistically significant differences ($P \leq 0.05$) between treatments. This was primarily due to the low degrees of freedom available for many of the analyses. With the number of animals per treatment ranging between two and five, differences in individual live mass gains could be substantial, which was detrimental to an effective statistical analysis of the trial. There were several cases where although an average difference in live mass gain of over 20% was measured, statistically significant differences could not be established. The production trends observed in both seasons, however, do highlight consistently superior treatments.

3.3 Results

Details of the live mass gain by treatment for each season are presented in Appendix 7 (page 113) and Appendix 8 (page 114) respectively.

3.3.1 Animal production

Averaged over all treatments (Table 3.4), live mass gain per hectare was substantially greater from Kikuyu HSR than either the veld or the Kikuyu LSR. Season 2, (although 33 days shorter) had substantially higher growth rates when compared on an ADG basis.

Table 3.4 Summary of live mass gain per hectare and ADG per treatment for Season 1 and Season 2

Season	Veld	Kikuyu HSR	Kikuyu LSR
Season 1 – Live mass gain (kg ha^{-1})	89.69	1061.59	346.00
Season 2 – Live mass gain (kg ha^{-1})	77.76	961.74	260.00
Season 1 – ADG (kg day^{-1})	0.83	0.88	0.91
Season 2 – ADG (kg day^{-1})	0.91	1.02	1.08

3.3.1.1 Live mass gain per hectare

The clearest trend for Season 1 (see Figure 3.1 overleaf) was the statistically significantly higher ($P \leq 0.05$) live mass gain per hectare on the Kikuyu HSR compared to either Kikuyu LSR or Veld. Doubling the stocking rate of kikuyu led to an almost threefold improvement in live mass production. The Kikuyu LSR had significantly higher live mass gains per hectare than the veld, though it is difficult to compare veld and kikuyu because of their different nutritional characteristics and stocking rates. Supplementation did not statistically significantly improve live mass production from veld. For kikuyu pastures, supplementation significantly improved live mass gain by over 200 kg ha^{-1} on Kikuyu HSR and 100 kg ha^{-1} on Kikuyu LSR. No significant differences were detected between individual supplements, although the Natural Protein supplement had the highest live mass yield for both kikuyu treatments.

Although shorter than Season 1 by 33 days Season 2 demonstrated very similar trends (see Figure 3.2 overleaf). Kikuyu HSR achieved statistically significantly higher ($P \leq 0.05$) live mass gains per hectare than either Kikuyu LSR or Veld. Supplementation significantly ($P \leq 0.05$) improved live mass gain, although none of the specialised ingredients significantly improved production compared to any other supplement. Avoparcin was nominally the best producing supplement in Season 2 with the highest live mass production in two of three grazing treatments.

Live mass production per hectare was lower in Season 2 due to a shorter production season, although this did not alter the trend of higher live mass gains per hectare from the Kikuyu HSR. The most productive supplements are detailed in Table 3.5 (below).

Table 3.5 Best live mass gain for best producing supplement per grazing treatment, averaged for both seasons (kg ha^{-1})

Grazing	Supplement	Live mass gain (kg ha^{-1})	Improvement in live mass gain (kg ha^{-1})
Veld	Grass	64.43	-
Veld	Avoparcin	95.96	31.53
Kikuyu HSR	Grass	834.87	-
Kikuyu HSR	Avoparcin	1107.63	272.76
Kikuyu LSR	Grass	295.00	-
Kikuyu LSR	Natural Protein	358.75	63.75

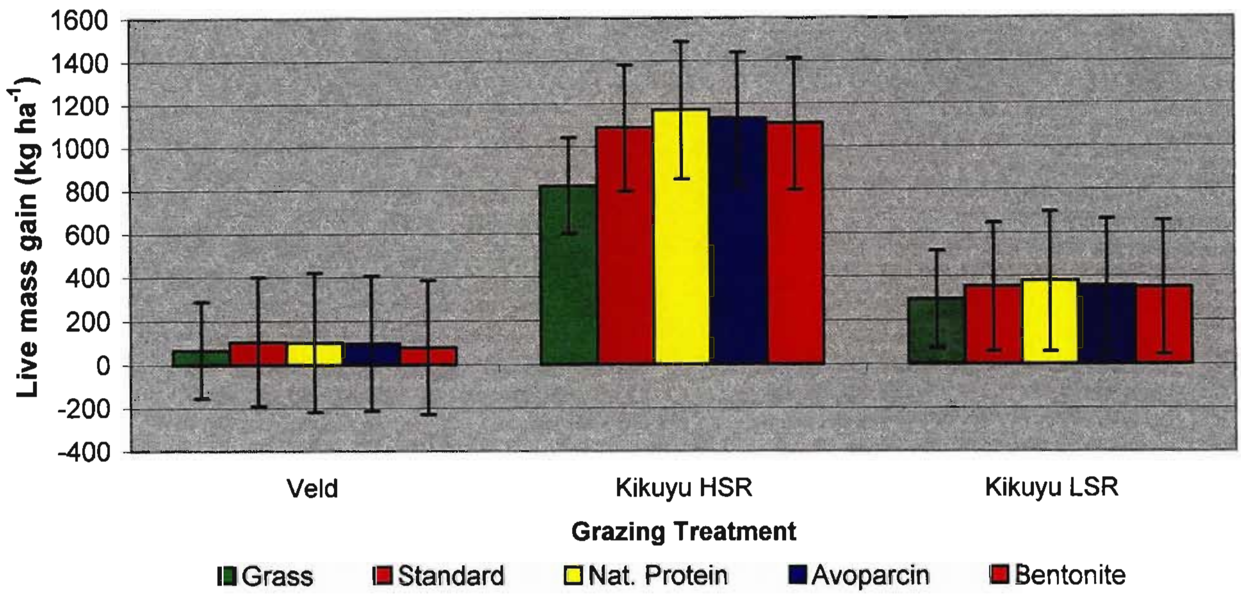

Figure 3.1 Beef production during Season1.

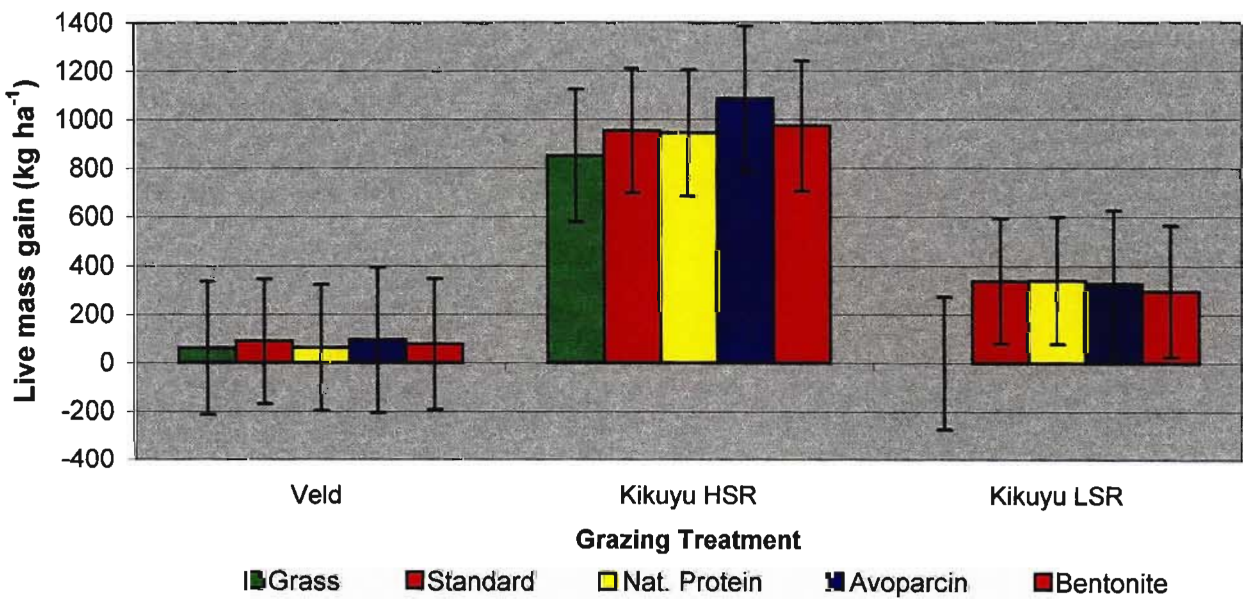

Figure 3.2 Beef production during Season 2.
Note: Grass was absent in Kikuyu LSR in Season 2.

3.3.1.2 Average daily gain

The second variable used to analyse animal production was Average Daily Gain (ADG), which measures the live mass gain effect of time (Season 2 was 33 days shorter). This measure is limited because it examines production on an animal, rather than a land area basis, but it illustrates the different rates of production in each season. Comparisons between seasons assumed that growth rate was similar at similar stages of the season.

Season 1 (see Figure 3.3 overleaf) there were no statistically significant differences in ADG between the different grazing treatments which ranged from 0.62 kg day^{-1} (Grass) to just under 1kg day^{-1} (Kikuyu HSR and Natural Protein). The ADG for the Kikuyu LSR, however, was consistently higher than on either the Kikuyu HSR or Veld.

Providing a supplement significantly increased ADG ($P \leq 0.05$) compared to un-supplemented treatments. Supplementation improved the rate of mass gain by a minimum of 150 g day^{-1}, though no significant differences in ADG were noted between individual supplements.

The ADGs in Season 2 were, on average, higher than in Season 1 (see Figure 3.4 overleaf) because of the shorter duration of Season 2. None of the grazing treatments achieved significantly different production, although, on average, ADGs from Kikuyu LSR were higher than either Kikuyu HSR or Veld. Supplementation again significantly improved ADG ($P \leq 0.05$), although not to the degree noted in Season 1.

Avoparcin supplement had the highest ADG for two of the three grazing treatments, while the Natural Protein supplement appeared to be less productive than for the same grazing treatments in the previous season. The dramatic decline in production from Natural Protein supplement on veld was attributed to two low-producing cattle that introduced negative bias to the data.

Comparing data from each season, the Kikuyu LSR consistently returned a higher ADG than either Kikuyu HSR or Veld (although the difference was not statistically significant). Supplementation significantly improved ADG ($P \leq 0.05$), though the magnitude of this change depends on the quality of the grazing available, with less improvement noted from higher quality kikuyu fodder.

3.3.2 Abattoir data

The data obtained from the abattoir were grouped into identification and quality information relating to conformation, fat cover, carcass grade, class and carcass mass.

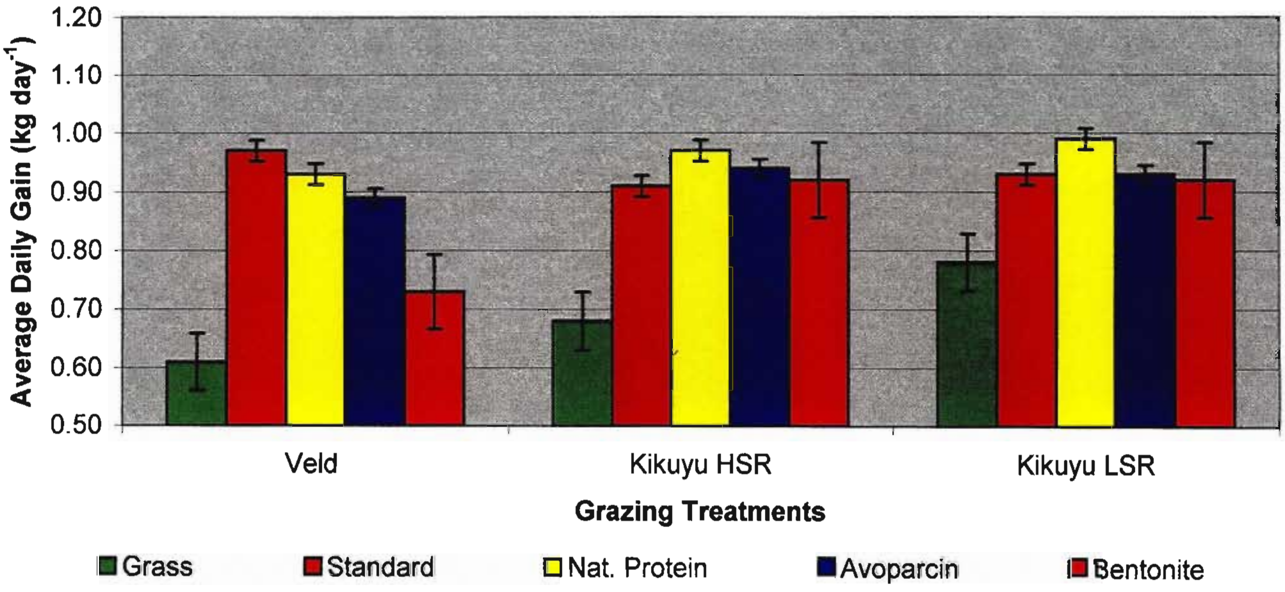

Figure 3.3 Average Daily Gain (kg day^{-1}) for Season 1.

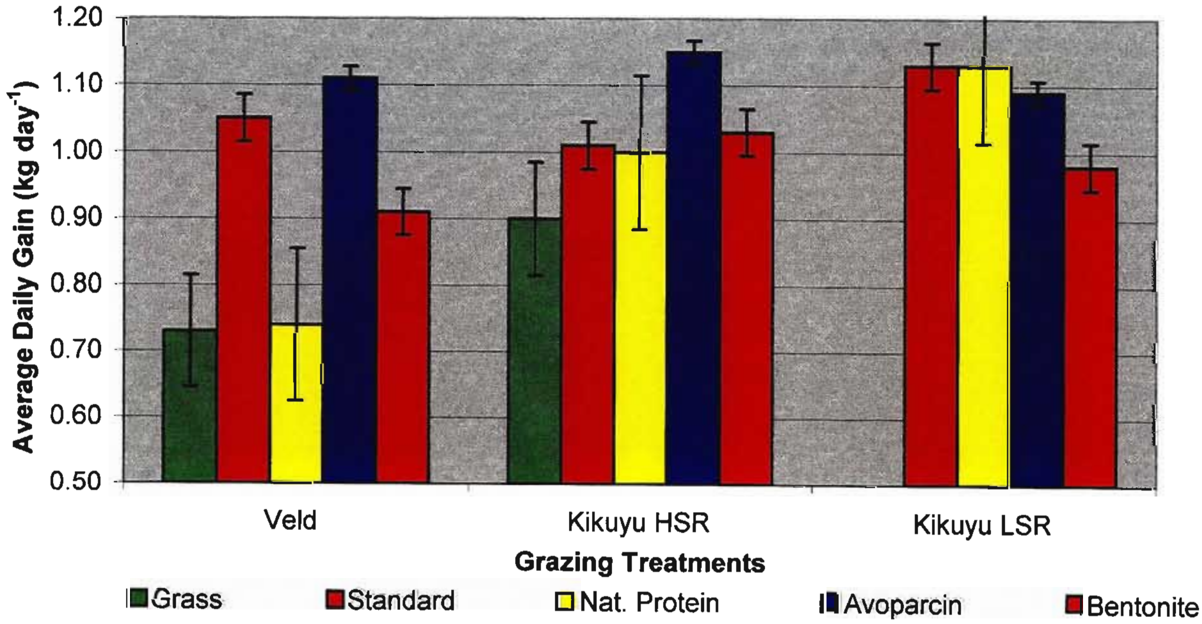

Figure 3.4 Average Daily Gain (kg day^{-1}) for Season 2.
Note: Grass was absent in Kikuyu LSR in Season 2.

The amount of fat present on a carcass is an important indicator of the final finished quality of the carcass, with a higher value indicating a deeper layer of fat. Carcass fat was evaluated on a five point scale relating total fat depth and distribution over the carcass (0 - emaciated; 5 - obese).

In both seasons, fodder flow restrictions meant the cattle that had to be sent to the abattoir before they had reached ideal body condition score (3). This was unfortunate, as supplement efficiency and live mass gain could not be associated with carcass quality.

In Season 2, adverse climatic factors limited the total time available for grazing. A nominal benefit was obtained by marketing the cattle during Easter when higher beef prices compensated for the significantly lower ($P \leq 0.05$) mass gains.

3.3.2.1 **Season 1**

At the end of Season 1, 6 of the 65 cattle were condition score 0, 32 condition score 1, 24 condition score 2 and 3 were condition score 3 (Table 3.6). Kikuyu LSR cattle had the best average condition score (1.70) while the Bentonite supplement had the best average condition score (1.54) over all treatments. Implantation had no significant influence in carcass condition score. As an aim of the trial was to achieve a carcass condition score of 3, none of the supplements under the trial conditions offered the potential for significant improvement in carcass quality.

Table 3.6 Individual carcass condition scores for summer supplemented cattle grazing veld or kikuyu in Season 1

	Grass		Standard		Natural Protein		Avoparcin		Bentonite		Average
Veld	1 1	**0 1 0**	1 2	**1 2 2**	0 1	**2 1 2**	0 0	**1 2 2**	2 1	**2 2 2**	1.25
Kikuyu HSR	2 2 1	**1 1 1**	3 2 1	**0 1 1**	1 1 2	**2 1 1**	2 2 2	**1 1 0**	2 2 1	**1 1 1**	1.33
Kikuyu LSR	2	**3**	1	**1**	1	**1**	2	**3**	2	**1**	1.70
Average Score	1.50	**1.00**	1.67	**1.14**	1.00	**1.23**	1.33	**1.43**	1.67	**1.43**	
Net Average	1.23		1.38		1.23		1.38		1.54		

Note: **Bold figures** identify animals with hormonal implants.

3.3.2.2 **Season 2**

As predicted, few cattle were in ideal condition, with less than 50% of the cattle scoring 2 or higher. Carcass condition scores (Table 3.7 overleaf) revealed that 6 carcasses scored 0, 24 scored 1, 31 scored 2 and only 1 scored 3. No distinct trends were noted for grazing treatments, with all three treatments having a range of condition scores. On veld, 58%

of the cattle achieved either 2 or 3 as a score. On the Kikuyu HSR pasture 47% of cattle scored 2 while on Kikuyu LSR pastures 50% of the cattle scored 2. Although none of these averages were statistically significant, it was interesting to note the improvement in carcass quality with a decrease in stocking rate.

Table 3.7 Individual carcass condition scores for summer supplemented cattle grazing either veld or kikuyu in Season 2

	Grass		Standard		Natural Protein		Avoparcin		Bentonite		Average
Veld	3 2	**2 1 1**	2 0	**1 2 2**	1 2	**2 2**	2 2	**2 2 1**	1 1	**1 1 2**	1.58
Kikuyu HSR	1 1 2	**0 0 2**	1 2 1	**2 2 2**	2 2 1	**1 2 2**	1 2 1	**1 1 1**	2 1 2	**2 1 0**	1.37
Kikuyu LSR	-	**-**	1	**1**	0	**0**	2	**2**	2	**2**	1.25
Average Score	1.60	**1.00**	1.17	**1.71**	1.30	**1.50**	1.67	**1.43**	1.30	**1.29**	
Combined Average	1.36		1.46		1.42		1.54		1.38		

Note: **Bold figures** identify animals that received hormonal implants.

Avoparcin was the best supplement for fattening cattle (Average score of 1.54) and surprisingly, veld proved to be the best grazing source (Average score of 1.58).

3.3.3 Hormone implants

Hormone implants have been promoted as providing a relatively inexpensive method of improving beef production. The data from this trial supports these findings, as implants statistically significantly ($P \leq 0.05$) improved live mass gain per day by 0.2kg day^{-1} (Table 3.8 overleaf). The improvement in ADG was most evident on veld grazing, possibly due to improved nutrient utilisation.

The most effective implantation treatment was Kikuyu LSR that achieved an average ADG of 1.1 kg day^{-1} over both seasons. None of the non-implanted treatments could match the gains of implanted cattle for any supplementation or grazing treatment.

A detailed breakdown of live mass gain for all treatments is presented in Appendix 7 and Appendix 8 on pages 113 and 114.

3.3.4 Sex ratios

During the design phase of the trial, care was taken to ensure an equal distribution of male and female cattle to all treatments in order to counter any potential differences in production potential between cattle sexes. Analyses showed that the male cattle gained mass at 0.1 kg day^{-1} more than their female counterparts (Table 3.9 overleaf). There was also an apparent improvement in ADG of 0.1 kg day^{-1} for both sexes in Season 2 (due to the shortened production season).

Table 3.8 The effect of hormonal implantation on ADG for both seasons (kg day^{-1})

	No Implant S1	No Implant S2	Average	Implant S1	Implant S2	Average
Veld	0.72	0.83	0.78	0.93	1.04	0.99
Kikuyu HSR	0.76	0.97	0.87	0.99	1.06	1.03
Kikuyu LSR	0.79	0.94	0.87	1.03	1.17	1.10
Average	0.76	0.91		0.98	1.09	

Note: S1 = Season 1; S2 = Season 2

Table 3.9 ADG of male and female cattle for both seasons (kg day^{-1})

Item	Season 1	Season 2
Male	0.91 (34)	1.02 (33)
Female	0.82 (31)	0.93 (29)

Note: bracketed number indicates sample size

3.3.5 **Stocking rate**

As cattle grow, their need for fodder increases and it is thus important to select an initial stocking rate that ensures consistent growth for the duration of the season. The three stocking rates set for the trial (veld, Kikuyu HSR and Kikuyu LSR) were maintained in both seasons.

Through each season, the effective stocking rates increase by approximately 60% (Table 3.10). This change was consistent for both seasons irrespective of grazing source. The veld stocking rate had the smallest increase although this was not statistically significant.

Table 3.10 Increase in beef production (live mass production per hectare) of veld and kikuyu pastures for Season 1 and Season 2 (kg ha^{-1})

	Season 1997 – 1998			Season 1998 – 1999		
	Initial	Final	% Change	Initial	Final	% Change
Veld	151.7	241.3	159.1	148.1	223.3	150.8
Kikuyu HSR	1577.4	2639.0	167.3	1785.3	2729.2	152.9
Kikuyu LSR	272.5	433.4	159.0	237.6	383.7	161.5

3.4 Discussion

In analysing the live mass production results two key questions must be considered. Firstly, have any treatments demonstrated a significant improvement in mass gain? Secondly, do any of the treatments show additional or unexpected properties that could influence utilisation or animal performance? Production refers to the ability of an animal to gain mass.

To compare treatments and allow meaningful conclusions to be drawn, a control was introduced which represented the most popular method of producing beef in the area, namely Veld (un-supplemented). Treatments with gains greater than the control were regarded as improved, because they enable better utilisation of the available resources. Conversely, treatments that produced less than the control indicate input factors less suited to the trial environment.

Live mass gain

Production data were reported on both an ADG and a land area basis. Each measure provides a different perspective on production and thus both are important to consider. Average daily gain is standardized for time, providing a method of comparing growth between seasons. Live mass gain per hectare allows for a comparison of treatments irrespective of grazing source. Particularly on improved grazing (pastures) it is important to optimize return per hectare relative to input costs.

As anticipated, cattle receiving high quality fodder and limited grazing competition (Kikuyu LSR treatment) provided the highest animal mass growth rate. Although these cattle had the highest individual animal growth, the negative effect of this on a "per hectare" basis was also evident. Optimizing stocking rate substantially improved overall system return relative to Kikuyu LSR, although trends in the pasture production data (Chapter 2) suggest that a slightly lower stocking rate may have reduced the negative effects of the midsummer drought and hence improved production further. Live mass production was constant for both seasons, demonstrating the consistent gain possible from kikuyu pastures (irrespective of climatic fluctuation).

Supplements were provided to try and increase live mass gain from each of the grazing treatments by compensating for nutritional deficiencies. Although veld cannot match the production per hectare possible from kikuyu, supplementing cattle grazing on veld did significantly improve live mass gain. Compared to the un-supplemented control, the Avoparcin supplement improved live mass gain by 31.54 kg ha^{-1} from veld grazing. For the Kikuyu HSR pasture, Avoparcin was the best producing supplement, improving live mass gain by 272.76 kg ha^{-1} compared to the control. For the Kikuyu LSR treatment, the Natural Protein supplement achieved the best live mass gains, improving production by 63.75 kg ha^{-1} compared to the un-supplemented control. The trend of higher live mass gains from supplements with improved dietary energy efficiencies (Avoparcin) suggests that energy was the principal nutrient that was limiting production. It is acknowledged that the basic composition of the supplement would have addressed most site-specific nutritional limitations. The conclusion that energy is the most limiting nutrient in the system was also supported by the poor production achieved by the Bentonite supplement (increased bypass protein).

Carcass characteristics

The goal of most beef producers is to consistently produce high quality carcasses, and any system that cannot produce these should be carefully evaluated. Carcass condition score (fat depth) was used as a measure of carcass quality.

Comparing the seasons, 52% of the cattle achieved a carcass fat score of 2 or higher in the Season 2 compared to 42% in Season 1 (as overall nutrition in Season 2 was superior).

In both seasons, there was no statistically significant difference in the carcass quality of supplemented or un-supplemented cattle. This raises the issue of whether summer supplementation is economically viable if it does not contribute to carcass condition (See Chapter 4)?

Implants

The use of hormonal implants to boost animal production has both management and financial implications. Many different factors influence the effective functioning of an implant, ranging from the quality of the forage, to the pre-existing hormonal balance in the animal and the length of production season.

The trial showed that un-implanted cattle gained an average of 0.82 kg day^{-1}, whilst implanted cattle gained 1.04 kg day^{-1} - an improvement of 0.22 kg day^{-1} averaged over the entire trial. The improved live mass gain of the implanted animals was attributed to increased energy efficiency from this product and this result complements the previous findings where the supplement that improved dietary energy (Avoparcin) improved mass gain (Sutton *et al.* 1994).

On veld, average production was improved by 0.21 kg day^{-1} when an implant was used. Live mass gain was improved by 0.16 kg ha^{-1} for the Kikuyu HSR grazing, and by 0.24 kg ha^{-1} for the Kikuyu LSR grazing. With respect to individual supplements, there was no statistically significant improvement in live mass gain for any supplements or grazing treatments.

In conclusion, these data have shown that hormonal implants can improve live mass production on any grazing source irrespective of quality. There may, however, be consumer resistance to the use of hormones in beef production. Although in terms of pure live mass production, the benefits of hormone implantation are shown, there is a growing resistance to artificially introduced hormones, coupled with a willingness to pay a premium price for implant-free "natural" beef which could offer additional production options to beef producers.

Sex ratios

Though an even distribution of sexes over all trial treatments was provided at the beginning of the trial, ensuring equal stocking rates took precedence, and in some cases sex distribution was unequal. This meant supplement or implant effects for the different cattle sexes could not be compared.

Male cattle tended to gain live mass faster than females (0.97 versus 0.87 kg day^{-1}). In Season 2, both sexes gained mass faster than in season 1, though the margin of increase was related to general diet improvement rather than better nutrient utilisation. An analysis of these data showed that castrated male steers have a better potential for mass gain than do female cattle of a similar age and size, as expected.

3.5 Conclusions

Many important issues influencing animal production have been discussed in Chapter 3, ranging from the production potential of the different grazing treatments, to the productivity of supplements and the effectiveness of hormonal supplementation.

Climate substantially influenced the trial results in both seasons. While Season 1 lacked rain during December (decreasing the quality of the grazing), Season 2 was shortened due to the late onset of rain.

In examining animal production, the first issue was the quality of the grazing material. As the primary source of nutrition, this material is crucial in determining the ceiling for production. There are two important issues, namely the quantity and quality of the grazing. Veld provided less grazing of lower quality than the kikuyu pastures. The vigorous growth habit of kikuyu provided large volumes of grazing material (complemented by the addition of fertilizer) which reduced the possibility of a shortage of grazing material. Cattle were able to produce better live mass gains from the kikuyu pastures than from the veld in both seasons. The stocking rate also had a substantial influence on final productivity, with the lower stocked kikuyu pasture (Kikuyu LSR) having the better individual animal production gains over both seasons.

Improved production implies a link between the quality of the fodder consumed and the duration of grazing. The trial demonstrated that the higher the baseline quality of the forage, the better the potential for improved cattle growth. Supplementary feeds provide a consistent source of nutrients that complement those gained from grazing, and are not intended as the sole source of nutrition for the cattle. Season 1 had generally lower quality forage and consequently lower average live mass production, whilst Season 2 had more consistent rainfall that produced better quality forage, which then improved live mass gains.

The combination of low stocking rates (compared to kikuyu) and nutrient deficiencies (protein and energy) meant that marked mass gains from veld grazing were unlikely, but there is potential to improve live mass gain by supplementing. Overall, the Standard and Avoparcin supplements improved production over all grazing treatments (averaged over both seasons). In contrast, the Bentonite supplement did not produce the anticipated live mass gains, as it utilised the available nutritional resources inappropriately (increased bypass protein without additional energy). The Natural Protein ration had a high production potential, but variation with respect to mass gain in Season 2 meant this ration under performed.

The kikuyu pastures presented a controlled management system where interventions like fertilization could be used to improve pasture growth. Furthermore, as kikuyu is known to be an energy deficient pasture species (Meaker 1998), an energy supplement could be used to address this particular problem. The Avoparcin supplement provided consistently improved animal production, above that from the other supplements. This was due to Avoparcin's increased contribution to ruminal energy (which was otherwise deficient in the diet). The lower stocking rate (Kikuyu LSR) treatment allowed cattle to select a better quality diet per animal, which contributed to improved live mass production. Natural Protein was the best performing ration on Kikuyu LSR, indicating that when cattle could select their diet, energy appeared less limiting and no distinct advantage was gained from using the Avoparcin ration.

It was unfortunate that neither season produced cattle of suitable condition for sale (carcass fat score 3). This was attributed to the adverse climate in both seasons, where insufficient rain delayed herbage growth during key growth periods. Furthermore, it was impossible to comment on the final potential of these supplements to produce finished beef cattle so the conclusions for this trial are made only with respect to live mass gain.

The trial demonstrated that hormonal ear implants could improve mass gain by at least 0.1 kg day^{-1}, although these beneficial results need to be examined in the light of consumer resistance to hormones, and may not mean an overall improvement in system profitability if a premium price could be paid for "implant-free" beef.

Although no system will provide ideal production in all situations, this trial showed that with careful selection of supplements that specifically address the nutritional problems, it is possible to increase the value of live mass gain in summer beef production systems.

Chapter 4 analyses how such supplementation affected the expected costs and benefits of the trial treatments.

CHAPTER 4

FINANCIAL ANALYSES OF THE SUMMER SUPPLEMENTED CATTLE PRODUCTION TRIAL

4.1 Introduction

The trial treatments outlined in the previous chapters can be viewed as potential changes in the organization of a summer beef production enterprise. To assess whether or not such changes would improve enterprise profit, the costs and benefits associated with each change need to be assessed. This chapter analyses the relative effect of each supplementation treatment on expected enterprise costs and returns using gross margin analyses, partial budgets and sensitivity analyses.

4.2 Materials and methods

Costs and returns for the trial are presented on a per hectare basis (as opposed to a per animal basis) for the following reasons:

a) beef farming is an extensive operation and, therefore, the hectare should be considered as the basic unit of production (Danckwerts 2000, pers comm);

b) data presented on a per hectare basis better represent overall treatment effects, because these effects are spread over several animals (reducing variation and error); and

c) beef farms tend to be managed on a per hectare basis. The basic philosophy being that a large number of cattle with poor condition scores tends to be worth more than few animals with greater individual merit (Danckwerts 2000, pers comm).

4.2.1 Gross margin analysis

The data were first analyzed by estimating treatment gross margins (treatment revenue minus attributable variable costs). This served, firstly, to describe the return above variable costs of the trial for the individual treatments. Secondly, it establishes a better understanding of the dynamics of the trial treatments and provides a way of gauging the effect of the different variables on gross margins.

4.2.2 Partial budget

The partial budget technique provides a quick method of assessing the financial effects of a proposed system change, where the overall farm business remains unchanged (Warren 1998). It estimates the likely effects that a change in management might have on future profitability (Johnson 1990). Partial budgeting evaluates production alternatives by estimating the effects of a proposed change on final profit (Norman & Coote 1971).

The partial budget layout in Table 4.1 shows how losses and gains can be used to assess a change from Treatment A to Treatment B. Costs associated with the long-term replacement of items such as feed and water troughs (e.g. depreciation) are excluded, as these costs are identical for all treatments.

Costs that remain constant when there are changes between treatments are not included in the analysis, as they have no effect on relative profit (although these costs would influence the overall system profitability). These include fencing, maintenance, animal transport, parasite control and general labour (including checking camps each day and weekly weighing, but not supplement feeding). Table 4.1 implies that a change between treatments will increase profit if the sum of the losses is less than the sum of the gains from making the change.

Table 4.1 Layout of a partial budget

Losses (R)		**Gains (R)**	
Lost revenue	(Treatment A)	Increased revenue	(Treatment B)
Increased costs	(Treatment B)	Saved costs	(Treatment A)
Net gain	(Losses ≤ Gains)	Net Loss	(Gains ≤ Losses)
	R XXX		R XXX

Source: Warren (1998)

It was confirmed by Patterson (pers. comm. 2002) that un-supplemented cattle grazing on veld are the most common summer beef production enterprise in the region and thus this system would provide a viable control against which to compare alternate treatments.

4.2.3 Sensitivity analysis

Sensitivity analyses are used to evaluate the robustness of net returns for each treatment. By adjusting the value of different input costs (to simulate the effect of a change in the value of each variable) the effects of cost fluctuations on expected net returns can be assessed. Treatments that remain profitable after these changes are robust systems that can be relied on to provide positive net returns, despite the cost fluctuations that farmers may realistically anticipate.

The factors selected for the sensitivity analyses were fertilizer cost, supplement cost and the purchase price of cattle (per kilogram live mass) because of their substantial contribution to the typical enterprise costs associated with summer beef production. These variables were increased and decreased by a plausible 10% to assess the sensitivity of net returns to changes in these key factors.

4.2.4 Sources of data

4.2.4.1 Grazing data

The expense of the grazing resource is a key input cost, and can be extremely variable, depending on the management inputs required. The two types of grazing (veld and kikuyu pastures) in the trial differed principally in terms of supplementary nutrition - veld was not fertilized, while the kikuyu was fertilized. Other costs included labour (for grazing maintenance) and mechanical costs (transport and burning).

Only fertilization costs varied between treatments and, hence, these were the only costs included in the partial budget calculations.

4.2.4.2 Animal production data

The costs of animal production were more variable than the grazing costs, and included the initial purchase price, establishment expenses (castration, implantation of Revelor-S® and ear tagging), labour (feeding, dipping and weighing), transport and abattoir fees. Although most of these remained constant implantation costs, supplement costs and animal purchase price were analysed as they fluctuated depending on treatment.

Revenue information was obtained from the Cato Ridge Abattoir where the cattle were slaughtered and sold. This information comprised a detailed breakdown of individual carcass prices and processing costs, with revenue per animal being linked to the carcass condition score and dressed carcass mass. This association complicated the analyses because a heavier animal of lower grade could return as much as a lighter animal of higher grade. The price paid for a carcass averages the quantity and quality of meat, rather than identifying a superior animal.

4.3 Results

After several detailed financial analyses, no treatments showed statistically different returns, principally because of the low number of animals per treatment (between one and three). Although further analyses may have no statistical significance, they can indicate financial trends and issues for further investigation. There were a total of 30 different production systems investigated each year, given the five supplementation treatments, three grazing treatments (veld; kikuyu at two stocking rates) and half of the cattle within each treatment being implanted with the growth hormone (Revelor ®). The productivity of these options was reviewed by season due to differences in costs and returns, and the climatic variation that introduced substantial variation in herbage production (see Chapter 2).

4.3.1 Gross margin analysis

A gross margin (gross margin minus attributable variable costs) was calculated for each treatment to estimate the net return before fixed costs for each treatment (the calculation are shown in Appendix 9(a) and (b) (pages 115 and 117 respectively). These gross margin data are summarised in Table 4.2.

Table 4.2 Gross margins of trial treatments (R ha^{-1})

		Grass	Standard	Natural Protein	Avoparcin	Bentonite	*Grass*	*Standard*	*Natural Protein*	*Avoparcin*	*Bentonite*
Veld	Season 1	220.83	212.35	-52.75	120.93	108.25	-3.57	261.81	104.29	12.76	113.71
Veld	Season 2	233.17	-162.98	-47.02	121.49	-26.08	43.39	617.86	208.72	295.84	51.32
Veld	Average	227.00	24.69	-49.89	121.21	41.09	19.91	439.86	156.51	154.30	82.52
Kikuyu HSR	Season 1	953.74	-853.33	-400.10	1939.73	223.83	456.79	-383.83	1363.56	348.31	444.95
Kikuyu HSR	Season 2	-420.58	-560.19	-1118.08	-2663.25	-1420.50	-1346.87	2103.00	-218.06	599.93	-225.73
Kikuyu HSR	Average	266.58	-706.76	-759.09	-361.76	-598.34	-445.04	859.59	572.75	474.12	109.61
Kikuyu LSR	Season 1	-584.01	-1029.26	-977.73	-906.79	-1732.48	-578.04	-3193.85	-1371.49	-1556.44	-707.14
Kikuyu LSR	Season 2	-	-1449.23	-2323.92	-868.75	-1066.54	-	-838.53	-1800.94	-1303.16	-846.82
Kikuyu LSR	Average	-	-1239.30	-1650.80	-887.77	-1399.51	-	-2016.19	-586.22	-1429.80	-776.98

Note: Bold treatments depict positive gross margins.
Italicised numbers represent implanted treatments.

The top three treatments with positive gross margins (averaged over both seasons) were Kikuyu HSR - Avoparcin - Implanted (average gross margin of R 474.12 ha^{-1}), Veld - Standard - Implanted (average gross margin R 439.86 ha^{-1}) and Veld – Un-supplemented – Un-implanted (average gross margin R 227.00 ha^{-1}). Due to a low stocking rate, the Kikuyu LSR treatments never achieved positive gross margins, but rather had an average negative gross margin of R 1 440.00 ha^{-1}. These consistent losses meant that no further analyses of the Kikuyu LSR treatments were considered.

The gross margin analyses (Table 4.2) show that production inputs need to establish their cost effectiveness before they can be used. The Veld supplementation treatments had positive gross margins in 15 of 20 treatments, and Kikuyu HSR in 8 of 20 treatments

In interpreting these results, it is important to consider the beef producer's attitude towards risk (Doll & Orazem 1978). Farmers who are risk averse may prefer the lower, but more consistent returns of the Standard - Implanted (R859.59 ha^{-1}) from Natural Protein - Implanted (R572.75 ha^{-1}) from grazing Kikuyu HSR. Producers who are less averse to risk may prefer the Standard - Implanted treatment (highest veld gross margin of R617.86 ha^{-1} in

Season 2) on veld or the Kikuyu HSR Standard - Implanted (R2103.00 ha^{-1}) and Avoparcin - Un-implanted (R1939.73 ha^{-1}) treatments that had the highest gross margins in Season 1.

Evaluating hormonal implants (averaged over supplements), un-implanted cattle (Veld and Kikuyu HSR) produced an average negative gross margin of R 178.69 ha^{-1}. Implanted cattle (Veld and Kikuyu HSR) produced an average positive gross margin of R 243.21 ha^{-1}.

Analysis of the gross margins shows that veld grazing returned a lower but more consistent gross margin per hectare. As the quality of the grazing increased, the gross margin per hectare increased, although there was a greater degree of fluctuation between treatments. Supplementation tended to provide little additional benefit to cattle grazing on veld, but improved the financial returns from cattle grazing on kikuyu pastures. Finally, hormone implantation improved the gross margins per hectare of beef from all grazing and supplement treatments. These treatments are discussed in more detail in section 4.3.2 below.

These data need to be interpreted with caution. Firstly, in neither season were cattle sold at an optimum "market-ready" condition (see Tables 3.6 & 3.7; page 56 and 57 respectively), because of limited fodder resources. Secondly, in Season 2, cattle received one month less grazing due to climatic restrictions. Thirdly, the low numbers of cattle per treatment increased the apparent variation in carcass quality and live mass gain.

4.3.2 Gross margin trends

The trial reported gross margins for 58 animal production options, over two seasons as two Kikuyu LSR grazing treatments were ignored in Season 2. Twenty-three of the production options had positive gross margins per hectare while 35 had negative gross margins (Table 4.2 page 66).

Veld

Fifteen of the 30 veld treatments had a positive gross margin per hectare (Table 4.2 page 66). Since the entire trial recorded only 23 positive gross margin treatments, the merit of the veld treatments can be easily gauged. Figure 4.1 (overleaf) shows that 9 out of 10 implanted production options recorded positive gross margins and that gross margins per hectare in Season 2 tended to exceed those in Season 1. Finally, the un-supplemented (control) treatment was close to, or improved on, the gross margin for the supplemented treatments, suggesting that the summer supplementation of cattle grazing on veld may not markedly improve income above variable costs.

Kikuyu HSR

The kikuyu pastures provided abundant levels of improved quality grazing, although these benefits were generated by additional costs (fertilizer and mechanical inputs).

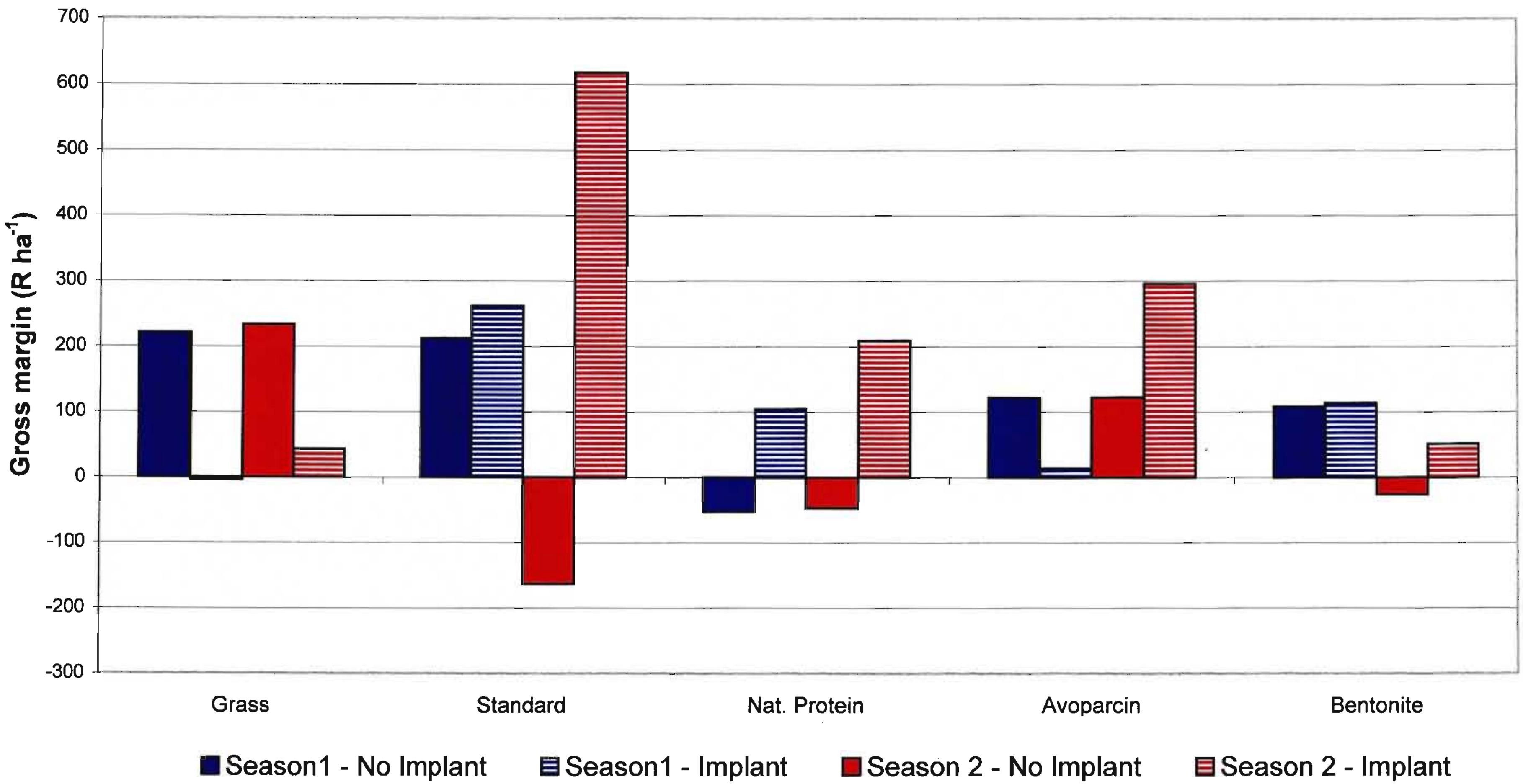

Figure 4.1 Gross margins for supplementation treatmetns for cattle grazing veld.

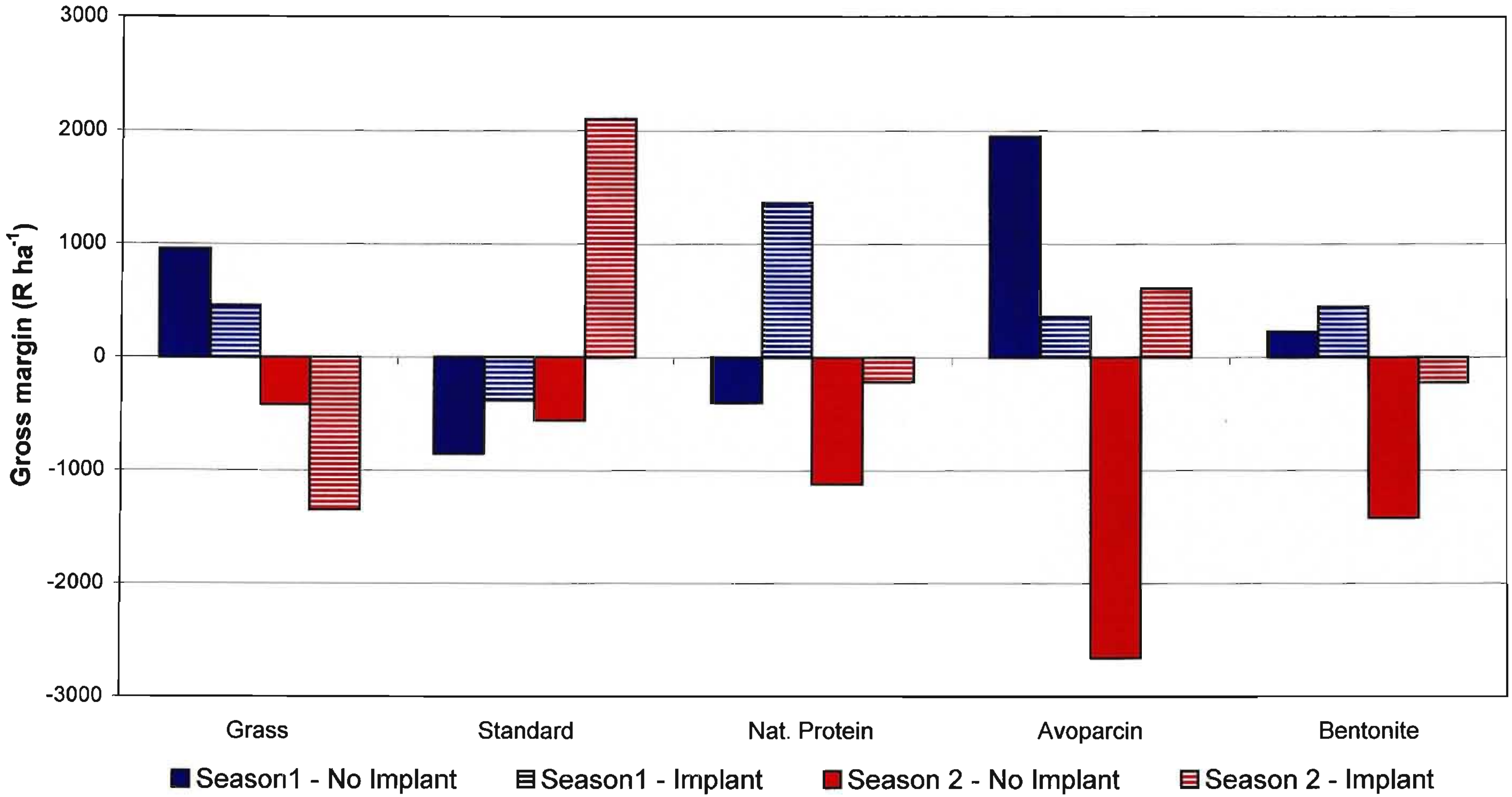

Figure 4.2 Gross margins for supplementation treatments for cattle grazing Kikuyu HSR.

The gross margin analysis (see Table 4.2 page 66; and Figure 4.2 page 69) showed that 9 of the 20 production options on Kikuyu HSR achieved positive gross margins per hectare. The most consistent performer was the Avoparcin supplement, which achieved a positive gross margin per hectare in three of the four production options. By contrast, both the Standard and Natural Protein supplements recorded negative gross margins for three of their four treatment groups. The potential value of the more intensive grazing system (Kikuyu HSR) was highlighted by the single highest gross margin of R 2103.00 ha^{-1} (Standard Implanted treatment) in Season 1, though this return was not matched in Season 2. By contrast, negative returns of up to R 2 663.25 ha^{-1} (Avoparcin, un-implanted) were also incurred.

As with the veld grazing, the consistent performance of the un-supplemented grazing must be noted. This production option did not give the highest return, but it was also (on average) not the worst option, suggesting that in situations where supplementation is not possible, kikuyu pastures could still play a role in improving summer beef production performance.

For both seasons, the Grass (un-supplemented) – Implanted treatment achieved lower gross margins than the un-implanted cattle production options.

Kikuyu LSR

The Kikuyu LSR pasture was stocked at half the stocking rate of the Kikuyu HSR pasture and the negative effect of this is apparent in Table 4.2 (page 66) and Figure 4.3 (overleaf). For this system to generate higher net returns individual animals need to produce far more efficiently to justify the high costs of pasture management.

No production option on the Kikuyu LSR pasture had a positive gross margin per hectare, with the lowest negative figure (R 578.04 ha^{-1}) being from the Grass Only production option. With supplementation, gross margin declined further (to a low of R 3 193.85 ha^{-1}; Standard, implanted in Season 1).

The costs of intensive systems have a great influence on net returns. The advantage of not supplying supplementary feed saved over R 500.00 ha^{-1} for the Grass only production option. These data demonstrate that although improved growth and body condition occurred through the use of supplements, these individual improvements may not justify the costs of the grazing system.

4.3.3 Partial budget analysis

Partial budgets were used to compare every treatment with every other treatment within the trial. The net gains or losses for the comparisons are summarises in Appendices 10(a) and 10(b) of Season 1 and Season 2 respectively (see pages 119 and 121). These calculations were made as per the methodology presented in Table 4.1 and the two example

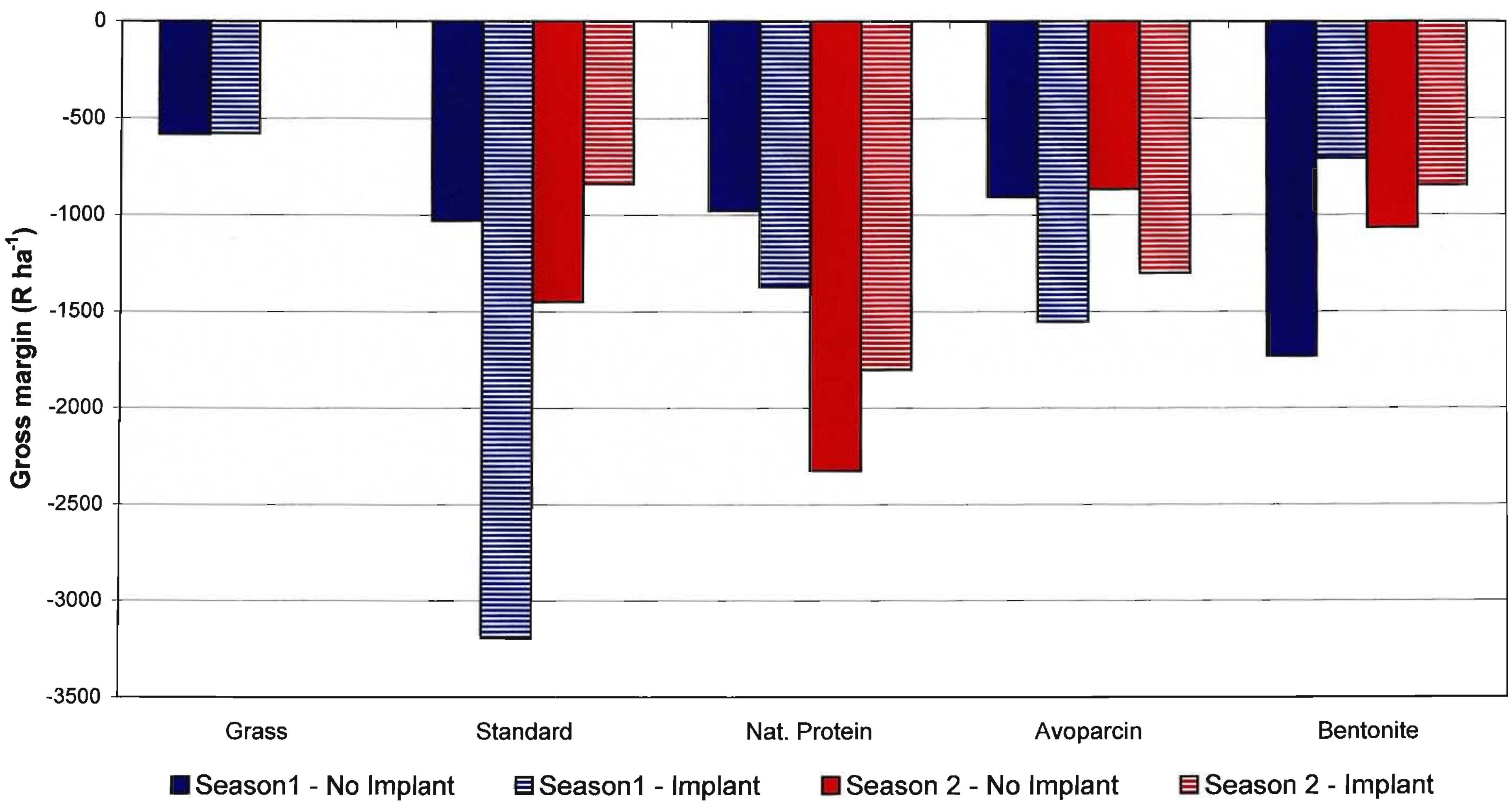

Figure 4.3 Gross margins for supplementation treatments for cattle grazing Kikuyu LSR.

partial budgets in Table 4.3 and Table 4.4 on page 72. The values for each treatment were calculated as per hectare average values for each cost and revenue item.

The discussion of the results will focus on comparisons between the control treatment (Treatment A: Veld – no supplement – no implant) and all other treatments, due to the volume of data and the key questions of the trial. Note that a negative value indicates that the control was more profitable than the treatment it was compared to. For example, Table 4.3 shows that Treatment B would reduce enterprise profit by R 604.67 ha^{-1} compared to Treatment A in Season 1. Conversely, Table 4.4 shows a profit increase of R 1 869.09 ha^{-1} if Treatment B replaced Treatment A in Season 2.

Table 4.3 Partial budget comparing Treatment A (Veld; no supplement; no implant) and Treatment B (Kikuyu HSR; Standard supplement; implanted) (per ha) for Season 1

Losses (R)		**Gains (R)**	
Revenue lost (Treatment A)	R	Revenue gained (Treatment B)	
Carcass value	819.96	Carcass value	10 263.68
Extra costs (Treatment B)		Costs saved (Treatment A)	
Cattle purchase price(R kg^{-1})	7 657.89	Cattle purchase price (R kg^{-1})	599.12
Hormone implantation	65.76	Hormone implantation	0
Supplemental feed	1 463.81	Supplemental feed	0
Fertilisation	1 460.05	Fertilisation	0
Sub-total	11467.47	Sub-total	10862.80
		Net Loss for enterprise change	R 604.67
Total	R 11467.47	Total	R 11467.47

Table 4.4 Partial budget comparing Treatment A (Veld; no supplement; no implant) with Treatment B (Kikuyu HSR; Standard supplement; implanted) (per ha) for Season 2

Losses		**Gains**	
Revenue lost (Treatment A)	R	Revenue gained (Treatment B)	R
Carcass value	981.81	Carcass value	13 121.05
Extra costs (Treatment B)		Costs saved (Treatment A)	
Cattle purchase price(R kg^{-1})	8 342.11	Cattle purchase price(R kg^{-1})	748.64
Implantation	65.76	Implantation	0
Supplemental feed	1 150.14	Supplemental feed	0
Fertilisation	1 460.05	Fertilisation	0
	11 999.87		13 869.69
Net Profit for enterprise change	R 1 869.09		
Total	R 13 869.82	Total	R 13 869.69

The two examples (Table 4.3 & Table 4.4) compared systems with different levels of input costs: a low-cost veld production system and intensively utilised (higher cost) kikuyu pastures. Although the kikuyu pastures have greater costs, the potential exists for the kikuyu-grazed system to return greater revenue. The veld had very low input costs that offset its substantially lower income per hectare. Depending on the efficiency of live mass production, either system could be profitable, as demonstrated in Table 4.3 & Table 4.4.

Very few treatments (see Table 4.5) were able to consistently produce more profit than the control treatment Veld (no supplement - no implant). Only the Veld (Standard implanted) treatment and the Kikuyu HSR (Avoparcin - implanted) could return positive changes in profit for both seasons. The Kikuyu HSR (Standard implanted) and the Kikuyu HSR (Natural Protein implanted) treatments did, however, give higher average positive profit changes per hectare averaged over the two seasons.

Several treatments added profits in one season, but were unable to sustain these returns for both seasons. Specialised circumstances may lead some producers to consider one of these more variable profit production options. Since the Kikuyu LSR treatments did not add profits for any treatment, these data were omitted from the overall partial budget analysis.

4.3.4 Partial budget trends

The gross margin analysis showed that veld grazing produced the highest gross margins per hectare, followed by the Kikuyu HSR and Kikuyu LSR pastures. Hormonal implantation was also confirmed as a technique that could improve profitability. The net profit changes for each partial budget critically evaluate these analyses compared to a control (veld –no supplement – un-implanted) (Table 4.5).

Table 4.5 Summary of partial budget net profit changes per hectare for control (Veld – un-supplemented - no implant) versus all treatments for Season 1

		Grass	Standard	Natural Protein	Avoparcin	Bentonite	Grass	Standard	Natural Protein	Avoparcin	Bentoni
Veld	Season 1	-	-8.49	-273.58	-99.08	-112.58	-224.41	**41.06**	-116.54	-207.25	-107.1
	Season 2	-	-396.14	-280.19	-111.02	-259.24	-189.77	**384.69**	-24.45	**62.68**	-181.8
	Average	-	-202.32	-276.89	-105.05	-185.91	-207.09	**212.88**	-70.5	-72.29	-144.4
Kikuyu HSR	Season 1	**732.91**	-1074.17	-620.93	**1727.41**	**2.98**	**235.96**	-604.67	**1142.73**	**135.98**	**224.1**
	Season 2	-653.74	-793.35	-1351.25	-2889.73	-1653.66	-1580.03	**1869.83**	-451.22	**373.46**	**-458.**
	Average	**39.59**	-933.76	-986.09	-581.16	-825.34	-672.04	**632.58**	**345.76**	**254.72**	-117.3
Kikuyu LSR	Season 1	-804.84	-1250.10	-1198.60	-1127.63	-1953.32	-798.88	-3414.68	-1592.33	-1774.57	-927.9
	Season 2	-	-1687.40	-2557.10	-1099.79	-1299.71	-	-1071.7	-2034.1	-1534.21	-108
	Average	-	-1468.75	-1877.83	-1113.71	-1626.6	-	-2243.19	-1813.3	-1654.39	-100

Note: **Bold** treatments depict profitable changes in treatments relative to the control.

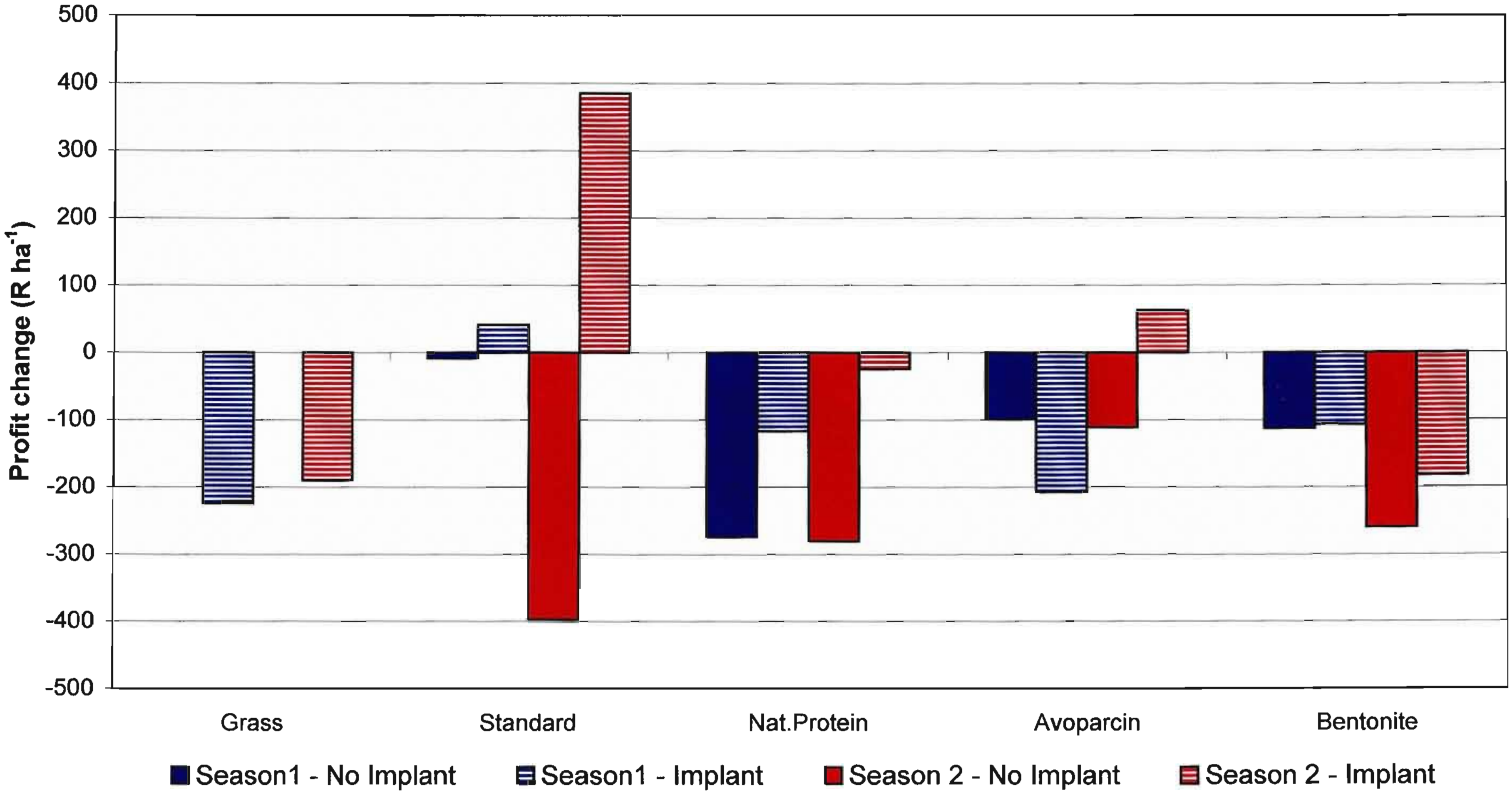

Figure 4.4 Partial budget profit changes relative to the control for supplement treatments for cattle grazing veld.

Veld

The partial budgets show very little financial incentive for changing from the control to a new production system (Table 4.5). Only three of the 18 treatments added profits compared to the control (see Figure 4.4 page 74). The largest gain in profit came from supplementing with the Standard ration and providing hormonal implants (for both seasons). In contrast, 15 of the cases reduced profits compared to the control. These results clearly show the potential negative effects of changing from the control to a supplementation treatment on veld.

Kikuyu HSR

In contrast to veld grazing, the Kikuyu HSR pastures offered an incentive to switch from the control as eight treatments added profit (see Table 4.5 page 73), with three Avoparcin production options providing added profit (see Figure 4.5 overleaf). The use of ear implants also improved profit relative to the control in most cases. The degree of differentiation between the results of individual treatments was more substantial than for veld, probably due to the more intensive nature of production on the kikuyu pastures.

Kikuyu LSR

As with the gross margin analysis, none of the Kikuyu LSR production options added to profit when compared to the control. All supplementation options on Kikuyu LSR reduced profit by between R798.88 and over R 3400 ha^{-1} (see Figure 4.6 on page 77).

4.3.5 Sensitivity analysis

The trial results were subjected to sensitivity analyses, where the values of several input variables were increased or decreased by a plausible 10% to establish the responsiveness of profit to these changes (Appendix 11 on page 123 summarises these results). The sensitivity analyses examined how profit changes with changes in initial beef purchase price, fertilizer cost and supplemental feed costs (Table 4.6) as these factors have the greatest influence on system cost. Each adjustment was made separately, holding all other costs constant, in order to help identify the costs that have the greatest impact on treatment profitability.

Table 4.6 Modifications to basic data for the sensitivity analysis

Cost item		- 10 %	Standard	+ 10 %
Live Purchase Price	*R* kg^{-1}	4.50	5.00	5.50
Fertilizer Price	*R* ha^{-1}	1314.05	1460.05	1606.06
Average Supplement Price	*R* kg^{-1}	0.77	0.85	0.95

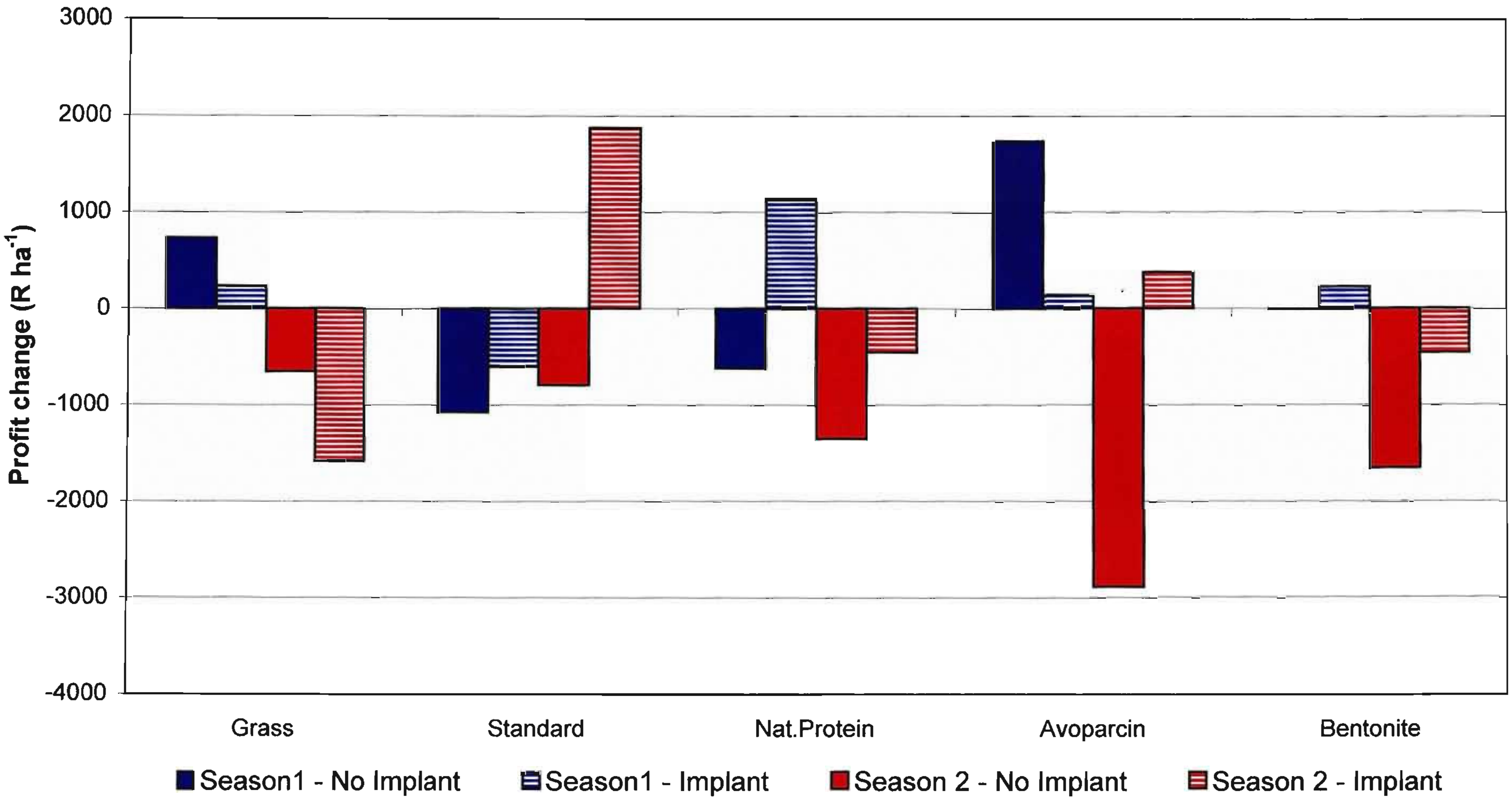

Figure 4.5 Partial budget profit changes relative to the control for supplement treatments for cattle grazing Kikuyu HSR.

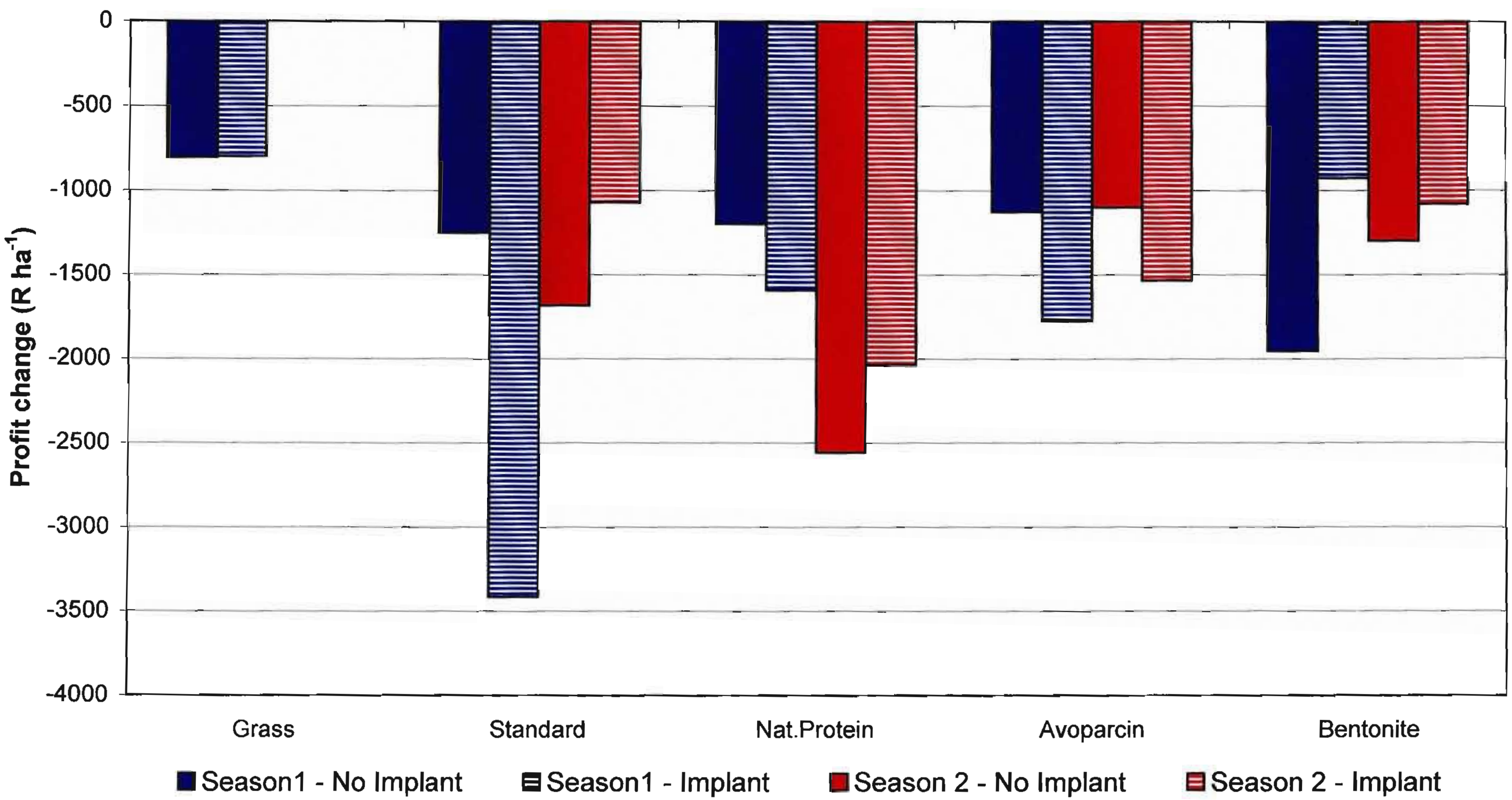

Figure 4.6 Partial budget profit changes relative to the control for supplement treatments for cattle grazing Kikuyu LSR.

Although the partial budget analysis identified the production options that added profit (relative to the veld (no supplement, no implant)), it is important to consider the sensitivity of these profits to a change in the price of key inputs. It was not possible to adjust the price paid per carcass because of the dynamic manner in which this price is determined, although it is acknowledged this price has a marked effect on the profitability of all systems. The results highlight treatments that may be vulnerable to unexpected but relatively minor increases in input prices. As the influences of these changes are different for each season, annual data were investigated as separate production options.

As anticipated, altering input costs had a marked influence on the profitability of the treatments (Table 4.7). The live purchase price of beef had the greatest influence on overall profitability, with a 10% price decline making five more treatments add to profit. Conversely, an increase in the beef purchase price was the most detrimental factor, causing only seven treatments to add to profit. Decreasing the price of fertilizer had no beneficial effect on any treatment, but two treatments did not add to profit when the fertilizer price rose by 10%. Decreasing the price of supplemental feed did not improve the number of treatments that added to profit, with an increase in supplement price causing two treatment to be less profitable compared to the control.

Table 4.7 Number of profitable treatments relative to the control, based on a sensitivity analysis that raised or reduced the value of key variables by 10%

Treatment		**Currently Profitable Treatments**	Beef price		Fertilizer price		Supplement price	
			- 10 %	+ 10 %	- 10 %	+ 10 %	- 10 %	+ 10 %
Veld	Season 1	1	2	0	1	1	2	1
	Season 2	2	2	2	2	2	2	2
Kikuyu HSR	Season 1	7	8	4	7	5	7	5
	Season 2	2	5	1	2	2	2	2
Kikuyu LSR	Season 1	0	0	0	0	0	0	0
	Season 2	0	0	0	0	0	0	0
Total		12	17	7	12	10	13	10

In all sensitivity analyses, price adjustments to the Kikuyu LSR treatments were unable to add profits. These findings highlight the need to consider costs, returns and price risk (variability in key input prices) when making grazing management decisions. They also demonstrate that for summer beef production, individual animal performance does not substitute for production per hectare as a management goal.

Overall, the sensitivity analysis showed that a decrease in input prices did not dramatically improve profitability, however, price increases caused a reduction in profits (Figure 4.7 overleaf). This trend occurred for all price increases, with a change in the beef purchase price having the most substantial effect.

Beef purchase price

The beef purchase price had a major influence on the change in profitability of each treatment. A 10% decline in price caused the total number of profit adding treatments to increase from 12 to 17, while a 10% increase in price decreased the number of treatments that Figure 4.7 added profits compared to the control to seven. Purchase price is an important factor because of it seasonal fluctuations. Purchasing cattle during the middle of the year takes advantage of lower demand and smaller body weight (cost) although costs could be higher due a longer retention period prior to sale.

Fertilizer cost

The change in fertilizer price only affected profit assed by the Kikuyu pasture treatments. Both the increase and decrease in price had little impact on the profit effect of the treatments. Changing the fertilizer price by 10% influenced the cost of fertilizer by approximately R150 per ton.

Supplement cost

The cost of feed has often been seen as the single biggest cost of an intensive beef operation. The provision of a better quality source of roughage (kikuyu pasture) helped reduce the reliance on feed supplements, reducing the proportional influence of feed price on added profit. The difference in cost (approximately R 120.00 per season) indicated that feed cost was only one of several factors influencing true cost of supplementation - other factors included the efficiency of utilisation and quality of the grazing. Although the composition of the rations differed to some degree, there were no significant changes in the price of rations for either season.

4.4 Discussion

The financial implication of any new production system needs to be carefully evaluated to try and ensure that adoption does not reduce expected profits. The gross margin analyses of the trial treatments helped to establish which treatments generated positive returns above attributable variable costs. Partial budgets compared the costs and returns for each treatment that change when switching from the control (veld grazing with no supplementation and no hormone implant) to establish whether or not a change in operation would have added to profit. Finally, sensitivity analyses investigated the robustness of each treatment profit

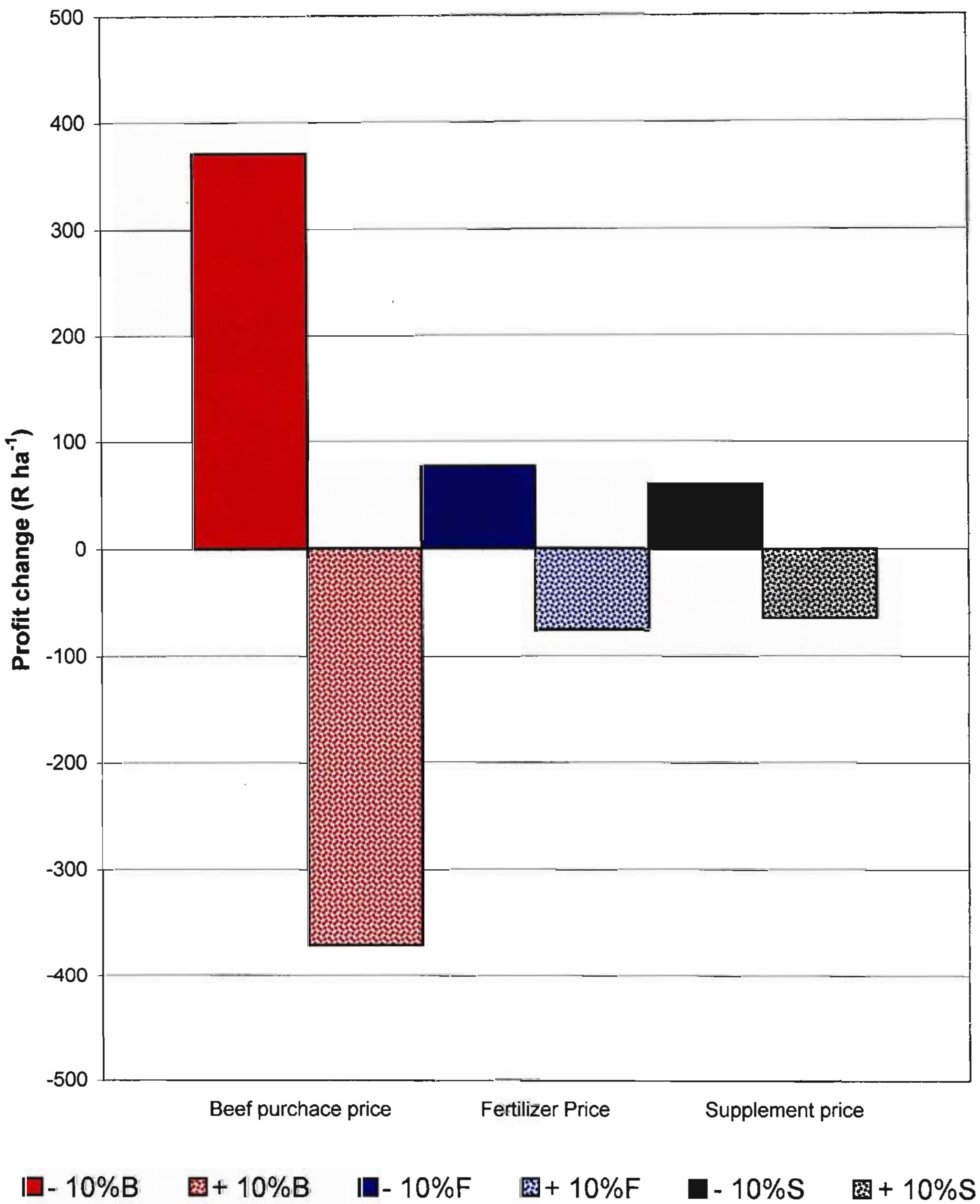

Figure 4.7 Influence on average profit change (R ha^{-1}) of a 10% increase or decrease in key input prices.

change to changes in the price of key inputs. Ultimately, the choice of system will depend on the individual producer's attitude towards risk and whether the treatment consistently produced positive returns above attributable variable costs (fixed costs were assumed to be constant over all treatments).

4.4.1 Analysis of financial returns

In critically assessing the returns from the range of trial treatments it is important to bear in mind that most commercial beef producers want to try and maximise profit, subject to the resource constraints and external situation (like droughts and policy changes) that they face on a sustainable basis. To achieve this aim, they are likely to be prepared to examine new production options and compare them to existing production systems.

Many of the trial treatments were able to generate a positive gross margin per hectare, but several of these could not maintain this across both seasons (a crucial factor when sustainable production is required). The Standard (Implanted), Grass (No Implant) and Natural Protein (Implanted) treatment gave the highest gross margins per hectare from veld. On the Kikuyu HSR treatment only the Avoparcin (Implanted) treatment returned a positive gross margin for each season. The Natural Protein (Implant), Standard (Implant) and Grass (No Implant) treatments gave positive gross margins only in one season, but returned a positive gross margin when data were averaged over both seasons. Although the Kikuyu LSR treatments were the most productive on a per animal basis (Chapter 3), gross margin analyses showed that they were not financially viable.

Comparing the trial treatments to the local summer beef production system (extensive veld grazing) using partial budgets showed which treatments had the potential to realise added profits in excess relative to the unsupplemeted veld grazing. The Standard (Implanted) grazing veld and Avoparcin (Implanted) grazing Kikuyu HSR treatments were the only treatments that demonstrated superior returns for both seasons and hence offer viable alternative methods of summer beef production.

The beef purchase price, fertilizer costs and supplement costs are variables that could easily reduce the profits of an enterprise. Sensitivity analyses assist in anticipating the potential effects of such price changes on profits added by treatments (see Figure 4.7 page 80). A 10% increase in these costs would decrease added profit by between R67.39 ha^{-1} for un-supplemented cattle on veld and R179.28 ha^{-1} for cattle supplemented with Avoparcin (Implanted) on Kikuyu HSR pastures.

4.4.2 Grazing

The financial analyses verify that although summer beef production can be improve by access to better quality grazing (kikuyu pastures), the added costs may exceed the added returns. Furthermore, the risks of fodder limitations from dryland kikuyu grown in a marginal climatic region are substantial, particularly as fodder yield is a difficult factor to accurately anticipate. In conditions of greater available moisture, where fodder production is more consistent, summer beef production from kikuyu could be more viable because of more consistent volume of forage production and an increase in forage quality.

4.4.3 Supplementation

Although the quality of the grazing had the most significant effect on live mass gain, the feeding of supplements can improve live mass gain, although this adds to the system production costs. Both veld and Kikuyu HSR pastures showed that they could add profits without the need for a supplementary feed.

From veld, the best supplement (averaged over both seasons) was the Standard (commercially available molasses based protein/energy/mineral ration), which produced an average gross margin of R 439.86 ha^{-1}. On the Kikuyu HSR, Avoparcin (Implanted) produced positive gross margins in both seasons and an average gross margin R 474.12 ha^{-1}. these results suggest that the most biologically productive ration is not necessarily the ration that generates the highest financial returns.

4.4.4 Implantation

Over all trial treatments, the hormonal growth implant (Revelor-S®) increased live mass gain. The implant cost (R 8.33 per animal) was offset by an average improvement in growth rate of 0.22 kg day^{-1}, which is the equivalent of 33 kg of beef over a 150-day season. This represents an improved return of R 165.00 per carcass (assuming a beef price of R10.00 kg^{-1} and a 50% dressing percentage).

Consumers' concerns over the use of hormonal growth products have resulted both in the drafting of legislation to control use, and price incentives for producers that do not use these products. The benefits of this product in terms of beef production cannot be disputed and in several treatments was the sole source of positive gross margins.

4.4.5 Stocking rate

The effect of stocking rates on profitability was only assessed on the Kikuyu pastures where cattle were initially stocked at 1.92 AU ha^{-1} and 0.89 AU ha^{-1}. In identically managed treatments, the heavier stocked pasture produced more beef per hectare and was substantially more profitable than the lightly stocked pasture as expected.

These data support earlier comments that intensive beef production systems must be evaluated on a yield per hectare basis rather that a per animal basis in order to meaningfully compare the potential financial returns of these systems.

4.5 Conclusions

The choice of a profitable summer beef production system is more complex than simply combining several production factors known to boost animal production. The interaction of these factors, together with their impact on costs and returns per hectare needs to be understood.

This trial indicated that the most consistent and reliable techniques for producing beef at the Ukulinga Research and Training Farm (averaged over the 1997-1998 and 1998-1999 seasons) on veld were achieved from implanted cattle, supplemented with the Standard supplement (gross margin of R 439.86 ha^{-1}). On Kikuyu, implanted cattle grazing at a high stocking rate and fed an Avoparcin-based supplement (R 474.12 ha^{-1}) gave positive returns above variable costs in both seasons.

The choice of production system is, however, influenced by the producer's attitude towards risk. Some farmers may choose treatments with a higher than average return (but higher risk) or potential variability in expected gross margin if they are relatively less risk averse. In this case, production options such as the un-implanted Avoparcin or the implanted Natural Protein (on Kikuyu HSR) would be production systems to consider.

Climate is an uncontrollable factor that can have a substantial effect on system productivity, particularly when ameliorating inputs such as irrigation are not available. In this trial a lack of rainfall caused the termination of each season before many of the cattle were ready to be marked. The price received per animal was thus considered to be significantly lower than could have been realized. Prevailing climate is a factor that farmers cannot manipulate, but needs to be anticipated when forecasting the likely financial returns of any summer beef production system.

The study results also indicate that during times of financial or climatic stress, the use of veld rather than Kikuyu pastures provides a better chance of realising profit (principally due to the saving achieved in pasture management costs).

The use of Revelor-S ® as a growth implant proved highly effective at improving beef production from both veld and Kikuyu. The issue of consumer resistance towards eating beef implanted with hormones needs to be mentioned. Depending on the price premiums, it may become possible to produce beef more profitably without using implants, if consumers are willing to pay more for "implant-free" beef. This could offer a niche market for some producers, although this production option would need to be re-evaluated when estimates of the detailed costs and benefits of such a system are available.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1 Introduction

The trial examined the effects of a range of supplementary feeds on summer beef production from either veld or kikuyu. The supplements were based on a commercially available protein/energy/mineral feed to which additives were added that either improved dietary energy or protein.

The objective of the trial was to analyze live mass production difference between these treatments on both a biological and financial basis. As grazing is the single most important resource in a beef production enterprise, production from the veld and kikuyu treatments are reviewed separately below.

5.2 Veld

For the purposes of this trial it was important to have an accurate understanding of the productive potential of veld in order to examine reasons for production trends over the two seasons. It is acknowledged that the quality and quantity of herbage can vary substantially in different areas as a result of different species composition. The nutritional analyses should not be extrapolated beyond the area of the trial as both management and environmental conditions are likely to vary markedly.

There is limited scope for managers to improve the productive potential of veld in the short term. Most of the primary factors influencing plant growth (moisture, temperature and soil nutrition) are influenced by climate. The trial showed that at the study site, rainfall was the most important climatic variable, with fluctuations in rainfall having a critical role, particularly in terms of the quality of the dry matter produced.

As a grazing resource the veld tended to provide a constant supply of moderate quality forage throughout either season. Although moisture stress decreased the quality of herbage produced, it did not decline to the extent that animal live mass gain was not possible. Given the relatively low crude protein and digestibility percentages of this veld, it was hoped that the generally poor quality of veld would provide a basis to evaluate the potential for supplementation to improve the live mass gain of beef animals.

The higher concentration of nutrients from supplements ensured that the live mass gains from all supplements were significant improved compared to those from un-supplemented cattle. The supplements comprised a Standard commercially available protein/energy/mineral supplement and three improved Standard rations with additives boosting either protein (Natural protein and Bentonite) or energy (Avoparcin). As suggested in the literature, the greatest live mass gains were achieved from the supplement with the energy additive (Avoparcin). Statistically, however, these differences were not significant and would need to be examined in greater depth in a follow-up study.

5.3 Kikuyu

Kikuyu is highly suited and widely used for the summer production of beef animals. It has abundant, high quality growth throughout the summer growing season and responds well to intensive, continuous utilization. This high production potential comes with high management requirements and other inputs such as irrigation. In addition, stocking rate has a substantial effect on the volume and quality of herbage produced. As the trial pastures were dry-land kikuyu, only rainfall could influence available moisture levels. These pastures were stocked at the recommended, and half the recommended stocking rate for the trial site area to establish if decreased competition for nutritional resources could sustainably improve animal live mass gain.

Herbage production data showed that kikuyu pastures were vulnerable to moisture stress, with a drought in Season 1 significantly decreasing both available herbage volume and quality. Although stocking rate did not appear to directly affect quality in times of moisture stress, lighter grazing pressure did reduce the negative impact of moisture stress.

As the nutrient quality of kikuyu is higher than veld, supplementation of kikuyu pastures was not expected to have as substantial an effect on live mass gain. Supplementation significantly improved the rate of live mass gain on kikuyu pastures (above that from veld). Past research has suggested that kikuyu is low in energy. The high mass gains from the Avoparcin supplement support these conclusions, particularly when compared to the poor performance of the high bypass protein ration (Bentonite).

Stocking rate is an important factor affecting production performance and the trial data demonstrate the importance of deciding on what unit of production (per animal or per hectare) to optimise production from. Whilst live mass gain per animal was highest in the Kikuyu LSR pasture where cattle had little nutritional stress, these cattle could not provide a sustainable return on a per hectare basis. As commercial beef farmers seek to maximise profit based on the resources with the greatest contribution to capital, land area must be the unit of measure when analysing the economics of production.

5.4 Financial analyses

Although improved biological production is important, it provides no incentive for producers to implement changes if it does not improve expected financial returns.

The third aspect of the trial was thus a financial analysis of the costs and returns of trial treatments to establish which treatment was most effective in improving enterprise performance. These analyses were conducted using gross margin analyses, partial budget analyses and sensitivity analyses.

The largest gross margin (averaged over both seasons) was achieved from implanted cattle grazing the Kikuyu HSR with the Avoparcin supplement. This gross margin was R 41.86 ha^{-1} more than the best treatment on veld (Standard supplement; implanted). Gross margins only examine the individual performance of a treatment and do not provide a comparison of potential profit increase relative to a standard control treatment. This was provided by the partial budget analyses that investigated the effect on profit of switching from the control (un-supplemented veld grazing) to each of the trial treatments. Previous data and consultation confirmed that the financial returns from the control were typical for the region (Patterson pers. comm. 2002). The treatment that produced the greatest added profit per hectare compared to the control was the Avoparcin supplement (with hormonal implants). While many treatments added profits in one season few maintained this return for both seasons. If a producer was prepared to accept greater risk (variability of returns), the Standard supplement (with hormonal implants) on higher stocked kikuyu pastures would return the greatest added profit above the control.

Finally, the effect of a change in input costs was investigated using sensitivity analyses where the initial beef purchase price, fertilizer price and supplement price were each increased and decreased by 10%. Only changes in the beef purchase price had a substantial influence on relative treatment returns, expressed most substantially on the higher stocked kikuyu pastures.

Veld grazing consistently added more profit than any other grazing source, principally due to the relatively low capital and input costs required to sustain these systems (particularly during adverse climatic conditions). To optimise financial returns, kikuyu pastures need to remain in optimum condition throughout the growing season, as adverse conditions quickly reduce quality and quantity, and so decrease financial return. High stocking rates can generate the improved financial returns to justify the added pasture management costs. Hormonal implants are also highly cost effective and consistently improved net returns in the trial treatments.

5.5 Conclusions and further research

It has been acknowledged that this trial was exploratory, considering a large number of treatment variables. Although the core conclusion for the trial remains that in climatically vulnerable environments, unwarranted expenditure must be avoided at all costs. In addition, care must be taken to differentiate between improved animal live mass gain and improved financial returns from the production system. It does not automatically follow that better animal performance will result after greater financial outlay.

From the study, several issues were identified that warrant further investigation;

- Irrigated kikuyu. Livestock production suffered because of the decline in quality of the kikuyu due to moisture stress. Irrigated kikuyu pastures could alleviate this problem and better express the production potential of the additives. The cost doing this will need careful analysis.
- Increased levels of supplements - The study maintained a consistent level of supplementation through the duration of the trial. Increasing the amount of supplement supplied in proportion to animal growth could both improve the final carcass condition of animals as well as speeding the finishing process.
- Price incentives for "organic" production (no antibiotics or hormonal growth promoters). It is interesting to note that subsequent to the completion of this study, the use of Avoparcin in livestock rations has been banned in both the European Union and the United States of America. Therefore, the future use of all feed additives are likely to receive greater scrutiny by consumer groups and this will impact markets directly. What will need to be established are the cost effective production strategies that allow economic beef production enterprises. These are likely to be grass based feeding strategies with only minimal market readiness taking place in intensive feed lot systems.

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Appendix 1 Weather data for Season 1and 2 summarised on a monthly basis

		Oct-97	Nov-97	Dec-97	Jan-98	Feb-98	Mar-98
Temperature	Average temperature	17.9	16.4	17.5	18.8	19	
	Highest	37.7	40.8	39	35.9	39.2	
	Lowest	9.1	9.4	10.4	13	13.9	
Rainfall (mm)	Monthly total	**49.2**	106.4	**59.4**	117	139	
	Long term mean	67	90	99	116	92	
	Cumulative total	49.2	155.6	215	332	471	
Evaporation	Total	103.7	93.1	137.9	126.1	110.9	
	Cum. Total	103.7	196.8	334.7	460.8	571.7	

		Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99
Temperature	Average temperature		19.9	19.8	21.63	21.15	21.8
Rainfall (mm)	Monthly total		79.2	84.4	118.2	**59.4**	21.4
	Long term mean		90	99	116	96	92
	Cumulative rainfall		79.2	163.6	281.8	341.4	362.6
Evaporation	Total	*	*	153.95	100.41	46.13	
	Cum. Total	*	*				

Appendix 2 - Veld condition - Raw Data

	1	2	3	4	5
Aris con	17	3	14	2	1
Aris jun	141	198	162	342	179
Both ins	1	2	16	1	0
Chlo gay	28	7	34	13	98
Cymb exc	60	203	63	131	12
Cyno dac	0	1	0	2	15
Dihe amp	0	5	0	0	0
Digi eri	0	0	1	0	0
Elio mut	1	0	0	0	0
Erog cur	44	35	96	70	111
Erog pla	6	1	3	0	8
Erog rac	45	35	99	58	49
Eus pasp	54	46	54	42	52
Forb	48	72	40	29	61
Hete con	74	24	48	8	9
Hypr hir	48	76	78	39	40
Meli ner	4	17	7	4	0
Meli rep	4	0	0	0	0
Micr caf	37	7	16	21	17
Pani max	1	19	5	8	4
Paspalum	0	0	0	1	0
Peni clan	0	0	0	0	3
Spor afr	1	0	1	1	10
Spor pyr	85	85	89	81	71
Them tri	235	120	121	114	201
Trag ber	17	3	3	0	2
Tris leu	49	41	50	33	57

Veld condition assessment

		Grazing	Benchmark		1		2		3		4		5	
Group	**Species**	**Value**	%	Score	%	Score	%	Score	%	Score	%	Score	%	Score
Increaser I	Bothriochloa bladii	2	1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Hyparrhmia filipendula	5	1	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tristachya leucothrix	9	8	72	4.9	44.1	4.1	36.9	5.0	45.0	3.3	29.7	5.7	51.3
	Cymbopogon excavatus	1	1	1	6.0	6.0	20.3	20.3	6.3	6.3	13.1	13.1	1.2	1.2
	Total		11		10.9		24.4		11.3		16.4		6.9	
Decreaser	Brachiaria serrata	3	2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Diheteropogon amplectens	8	0	0	0.0	0.0	0.5	4.0	0.0	0.0	0.0	0.0	0.0	0.0
	Themeda triandra	10	44	440	23.5	235.0	12.0	120.0	12.1	121.0	11.4	114.0	20.1	201.0
	Digiteria erantha	5	3	15	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.0	0.0	0.0
	Melinis nerviglumis	2	1	2	0.4	0.8	1.7	3.4	0.7	1.4	0.4	0.8	0.0	0.0
	Panicum maximum	10	0	0	0.1	1.0	1.9	19.0	0.5	5.0	0.8	8.0	0.4	4.0
	Eustachys paspaloides	6	0	0	5.4	32.4	4.6	27.6	5.4	32.4	4.2	25.2	5.2	31.2
	Total		50		29.4		20.7		18.8		16.8		25.7	
Increaser IIa	Eragrostis capensis	2	2	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Harpochloa flax	3	2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Heteropogon contortus	6	3	18	7.4	44.4	2.4	14.4	4.8	28.8	0.8	4.8	0.9	5.4
	Chloris gayana	9	0	0	2.8	25.2	0.7	6.3	3.4	30.6	1.3	11.7	9.8	88.2
	Total		7		**10.2**		**3.1**		**8.2**		**2.1**		**10.7**	
Increaser IIb	Eragrostis curvula	5	1	5	4.4	22.0	3.5	17.5	9.6	48.0	7.0	35.0	11.1	55.5
	Eragrostis plana	3	0	0	0.6	1.8	0.1	0.3	0.3	0.9		0.0	0.8	2.4
	Eragrostis racemosa	2	3	6	4.5	9.0	3.5	7.0	9.9	19.8	5.8	11.6	4.9	9.8
	Hyparrhrnia hirta	6	6	36	4.8	28.8	7.6	45.6	7.8	46.8	3.9	23.4	4.0	24.0
	Sporobolus africanus	3	1	3	0.1	0.3	0.0	0.0	0.1	0.3	0.1	0.3	1.0	3.0
	Sporobolus fimbriatus	7	2	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bothriochloa insculpta	3	2	6	0.1	0.3	0.2	0.6	1.6	4.8	0.1	0.3	0.0	0.0
	Eragrostis superba	4	1	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Eragristis chloromelas	2	2	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sporobolus pyamidalus	2	1	2	8.5	17.0	8.5	17.0	8.9	17.8	8.1	16.2	7.1	14.2
	Total		19		**23.0**		**23.4**		**38.2**		**25.0**		**28.9**	
Increaser IIc	Microchloa caffra	1	1	1	3.7	3.7	0.7	0.7	1.6	1.6	2.1	2.1	1.7	1.7
	Paspalum scrobiculatum	0	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	Aristida barbicollis	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Perotis patens	0	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Forb	0	5	0	4.8	0.0	7.2	0.0	4.0	0.0	2.9	0.0	6.1	0.0
	Sedge	0	2	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cynodon dactylon	3	0	0	0.0	0.0	0.1	0.3	0.0	0.0	0.2	0.6	1.5	4.5
	Melinis repens	1	0	0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Aristida congesta	0	0	0	1.7	0.0	0.3	0.0	1.4	0.0	0.2	0.0	0.1	0.0
	Tragus beteronianus	1	0	0	1.7	1.7	0.3	0.3	0.3	0.3	0.0	0.0	0.2	0.2
	Total		11		**12.3**		**8.6**		**7.3**		**5.5**		**9.6**	
Increaser III	Asistida juncuformis	0	2	0	14.1	0.0	19.8	0.0	16.2	0.0	34.2	0.0	17.9	0.0
	Elionurus muticus	0	0	0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total		2		**14.2**		**19.8**		**16.2**		**34.2**		**17.9**	
	Grand Total		100	653		473.9		341.2		411.3		296.8		497.6

Appendix 3 - Correspondence analysis data

NAME	Type	Axis 1	Axis 2
Them tri	Dec	-58	-23
Eust pas	Dec	-47	-14
Digi eri	Dec	-28	-128
Meli ner	Dec	52	-113
Dihe amp	Dec	63	-183
Pani max	Dec	159	6
Tris leu	Inc 1a	-31	14
Cymb exc	Inc 1a	118	-46
Chlo gay	Inc 2a	-101	93
Hete con	Inc 2a	-76	-116
Erog pla	Inc 2b	-134	-29
Spor afr	Inc 2b	-128	166
Erog cur	Inc 2b	-29	70
Both ins	Inc 2b	-29	49
Erog rac	Inc 2b	-25	32
Spor pyr	Inc 2b	-5	-11
Hypr hir	Inc 2b	29	-24
Aris con	Inc 2c	-109	-152
Trag ber	Inc 2c	-98	-106
Cyno dac	Inc 2c	-91	217
Micr caf	Inc 2c	-49	-18
Meli rep	Inc 2c	-30	-125
Paspalum	Inc 2c	101	193
Elio mut	Inc 3	-275	-122
Forb	Inc 3	22	-47
Aris jun	Inc 3	47	46

	Axis 1	Axis 2
Dec	141	-455
Inc 3	-206	-123
Inc 1	87	-32
Inc 2a	-101	-23
Inc 2c	-276	9
Inc 2b	-321	253

Key:	
Dec	Decreaser
Inc I	Increaser I
Inc IIa	Increaser IIa
Inc IIb	Increaser IIb
Inc IIc	Increaser IIc
Inc III	Increaser III

Appendix 4 - Disk meter data

Day	Date		Veld	Kikuyu HSR	Kikuyu LSR
1	23.9.97	1	1115	1179	1046
		2	1231	1276	1091
		3	1257	1117	1081
		4	1276	1087	1038
		5	1243	1186	
		6	1126	1135	
		7	1304	1119	
		8	1314	1293	
		9	1174	1196	
		10	1219	1260	
14	6.10.97	1	1305	1363	1146
		2	1316	1375	1173
		3	1292	1453	1153
		4	1384	1456	1186
		5	1380	1351	
		6	1128	1383	
		7	1314	1473	
		8	1234	1458	
		9	1263	1334	
		10	1316	1357	
28	20.10.97	1	1341	1564	1791
		2	1349	1674	1764
		3	1361	1641	1717
		4	1297	1627	1720
		5	1362	1687	
		6	1343	1629	
		7	1364	1624	
		8	1356	1595	
		9	1360	1681	
		10	1292	1658	
42	3.11.97	1	1845	2026	2119
		2	1856	1860	2072
		3	1715	1937	2085
		4	1688	1825	2109
		5	1709	1863	
		6	1842	1982	
		7	1786	1925	
		8	1815	1912	
		9	1674	1860	
		10	1832	1931	
56	17.11.97	1	1637	2719	2472
		2	1570	2630	2582
		3	1595	2723	2488
		4	1613	2570	2561
		5	1592	2532	
		6	1658	2637	
		7	1660	2587	
		8	1668	2572	
		9	1609	2640	
		10	1656	2646	
70	1.12.97	1	1775	2947	3130
		2	1657	2923	3099
		3	1622	3006	3119
		4	1746	2858	3182
		5	1680	2989	
		6	1739	3010	
		7	1764	2818	
		8	1791	2831	
		9	1596	2931	
		10	1784	2938	

Day	Date		Veld	Kikuyu HSR	Kikuyu LSR
1	25.11.98	1	1293	1744	1062
		2	1407	1662	978
		3	1396	1695	1079
		4	1255	1488	977
		5	1388	1687	
		6	1295	1636	
		7	1227	1597	
		8	1243	1434	
		9	1341	1455	
		10	1235	1507	
16	9.12.98	1	1505	3227	1453
		2	1593	3082	1294
		3	1523	3157	1387
		4	1456	3176	1472
		5	1416	3195	
		6	1456	3120	
		7	1510	3211	
		8	1416	3182	
		9	1442	3141	
		10	1541	3231	
30	23.12.98	1	1584	2919	2435
		2	1643	2948	2381
		3	1603	2975	2423
		4	1619	2981	2436
		5	1562	2846	
		6	1519	2894	
		7	1543	2965	
		8	1551	2896	
		9	1580	2942	
		10	1616	2912	
44	6.1.99	1	1394	2794	2727
		2	1420	2855	2591
		3	1456	2740	2647
		4	1440	2836	2653
		5	1366	2753	
		6	1361	2855	
		7	1463	2806	
		8	1418	2614	
		9	1378	2852	
		10	1410	2756	
58	20.1.99	1	1537	3159	3561
		2	1660	3169	3656
		3	1624	3176	3631
		4	1655	3143	3649
		5	1510	3292	
		6	1484	3211	
		7	1658	3142	
		8	1474	3231	
		9	1573	3275	
		10	1673	3109	
72	3.2.99	1	1797	4033	3868
		2	1876	4155	3807
		3	1886	4148	3753
		4	1975	4134	3864
		5	1949	4227	
		6	1864	4122	
		7	1953	4052	
		8	1957	4196	
		9	1903	4083	
		10	1893	4035	

84	15.12.97	1	1345	2213	2486
		2	1351	2274	2442
		3	1199	2154	2510
		4	1309	2139	2468
		5	1328	2287	
		6	1348	2220	
		7	1225	2235	
		8	1324	2261	
		9	1251	2132	
		10	1336	2261	
105	5.1.97	1	1397	2202	2904
		2	1395	2227	2843
		3	1368	2065	2882
		4	1432	2069	2774
		5	1363	2185	
		6	1346	2274	
		7	1406	2268	
		8	1387	2177	
		9	1360	2236	
		10	1433	2133	
119	19.1.98	1	1814	3524	3378
		2	1747	3435	3479
		3	1772	3528	3441
		4	1790	3375	3398
		5	1769	3337	
		6	1784	3341	
		7	1837	3392	
		8	1846	3377	
		9	1835	3545	
		10	1833	3451	
133	2.2.98	1	1786	3282	2925
		2	1633	3349	2942
		3	1836	3319	2737
		4	1738	3295	2735
		5	1783	3378	
		6	1787	3210	
		7	1741	3361	
		8	1890	3382	
		9	1825	3190	
		10	1752	3203	
147	16.2.98	1	1728	3185	2673
		2	1858	3042	2723
		3	1756	3087	2697
		4	1816	3009	2745
		5	1826	3052	
		6	1844	3128	
		7	1799	2981	
		8	1964	3076	
		9	1993	2987	
		10	1867	3171	
154	24.3.99	1	2106	3350	3443
		2	2133	3345	3549
		3	2038	3453	3526
		4	2274	3343	3561
		5	2191	3357	
		6	2221	3456	
		7	2221	3356	
		8	2241	3390	
		9	2259	3405	
		10	2257	3428	
93	24.2.99	1	1904	3949	3729
		2	1931	3939	3824
		3	2109	3876	3731
		4	2144	3733	3726
		5	2066	3769	
		6	2121	3802	
		7	2019	3833	
		8	2007	3820	
		9	1892	3844	
		10	2090	3848	
107	10.3.99	1	2074	3381	3701
		2	2161	3443	3683
		3	2144	3423	3575
		4	2076	3473	3683
		5	2099	3419	
		6	2234	3348	
		7	2235	3389	
		8	2129	3459	
		9	2245	3330	
		10	2047	3417	
121	24.3.99	1	2046	3441	3530
		2	2269	3356	3535
		3	2233	3316	3558
		4	2243	3372	3457
		5	2349	3340	
		6	2093	3289	
		7	2267	3412	
		8	2083	3446	
		9	2182	3428	
		10	2171	3477	

Trial days	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
1	23.9.97	1	58.55	47.37	47.25
		2	60.90	48.20	44.32
		3	60.05	42.35	45.65
		4	55.83	44.90	48.23
		5	56.76	44.27	
		6	55.34	47.92	
		7	56.89	42.30	
		8	57.26	45.35	
		9	53.48	44.60	
		10	53.83	44.96	
14	6.10.97	1	58.07	52.34	51.78
		2	61.99	47.98	49.63
		3	56.56	50.82	48.86
		4	59.21	48.68	50.47
		5	58.72	50.64	
		6	58.66	48.46	
		7	59.04	48.65	
		8	55.20	46.29	
		9	59.51	49.99	
		10	57.15	51.39	
28	20.10.97	1	55.00	51.79	52.94
		2	55.34	50.54	54.38
		3	58.71	54.39	52.26
		4	59.56	49.35	50.79
		5	60.17	53.56	
		6	56.43	55.22	
		7	56.04	55.91	
		8	55.55	49.61	
		9	55.64	51.24	
		10	59.25	52.26	
42	3.11.97	1	55.45	52.09	54.75
		2	61.96	51.98	53.96
		3	60.02	50.53	53.72
		4	56.27	52.72	54.53
		5	52.55	50.71	
		6	56.61	55.52	
		7	61.55	55.97	
		8	52.82	52.06	
		9	56.23	51.42	
		10	55.40	54.57	
56	17.11.97	1	52.83	55.02	52.35
		2	51.11	59.39	57.04
		3	53.85	53.63	55.72
		4	56.20	51.73	56.62
		5	54.57	52.15	
		6	57.22	50.56	
		7	56.20	54.68	
		8	56.80	54.55	
		9	59.33	53.05	
		10	54.23	54.79	
70	1.12.97	1	52.25	56.44	61.69
		2	50.62	59.61	58.82
		3	54.23	58.48	61.24
		4	59.41	59.44	57.87
		5	50.94	57.68	
		6	52.96	56.95	
		7	51.95	57.53	
		8	50.40	59.65	
		9	51.19	63.49	
		10	55.48	60.59	

Trial days	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
2	25.11.98	1	56.06	45.26	50.49
		2	60.52	47.32	47.24
		3	58.28	46.24	47.88
		4	60.23	48.33	50.45
		5	57.21	49.02	
		6	62.93	53.32	
		7	61.86	50.72	
		8	61.61	51.89	
		9	57.52	46.25	
		10	61.07	45.02	
16	9.12.98	1	59.10	50.73	52.84
		2	55.43	49.91	50.51
		3	57.65	47.25	52.91
		4	56.64	50.83	49.33
		5	55.09	50.45	
		6	55.88	52.17	
		7	60.17	48.89	
		8	55.09	51.87	
		9	62.21	50.67	
		10	59.13	50.12	
30	23.12.98	1	60.57	56.13	54.52
		2	61.73	50.59	53.18
		3	57.37	56.24	52.11
		4	55.94	54.77	53.92
		5	57.51	56.63	
		6	58.44	53.36	
		7	54.21	55.59	
		8	59.47	55.11	
		9	59.34	55.82	
		10	55.70	52.21	
44	6.1.99	1	54.92	56.58	57.29
		2	57.93	57.76	52.87
		3	58.51	57.45	55.40
		4	57.81	54.96	54.16
		5	56.79	59.24	
		6	53.92	58.60	
		7	54.97	55.17	
		8	56.69	54.76	
		9	58.46	57.71	
		10	53.39	56.44	
58	20.1.99	1	52.82	62.20	61.09
		2	52.57	59.98	59.49
		3	52.11	63.42	61.23
		4	49.35	64.63	60.25
		5	48.79	65.57	
		6	54.61	61.96	
		7	54.92	61.13	
		8	52.59	62.73	
		9	49.22	63.07	
		10	51.66	59.80	
72	3.2.99	1	48.83	62.20	58.09
		2	42.57	66.82	62.48
		3	48.19	67.42	63.03
		4	43.53	65.93	60.72
		5	48.79	65.57	
		6	44.61	67.96	
		7	46.92	61.13	
		8	42.09	66.72	
		9	48.22	65.07	
		10	44.66	61.80	

Trial days	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
84	15.12.97	1	44.54	55.09	54.68
		2	46.86	51.18	59.10
		3	48.36	54.79	55.33
		4	42.02	53.35	60.70
		5	42.36	52.30	
		6	47.81	52.54	
		7	46.58	50.91	
		8	47.19	55.12	
		9	45.07	56.78	
		10	43.55	57.47	
105	5.1.98	1	42.51	53.52	56.52
		2	47.81	55.95	54.49
		3	44.49	52.75	55.44
		4	44.92	54.56	54.73
		5	48.69	53.69	
		6	46.38	54.18	
		7	50.08	50.27	
		8	48.06	51.17	
		9	47.27	53.58	
		10	48.70	54.38	
119	19.1.98	1	46.55	56.26	55.28
		2	45.65	52.48	54.53
		3	42.94	52.78	56.18
		4	46.34	58.04	54.62
		5	42.69	59.27	
		6	47.89	53.02	
		7	44.62	55.57	
		8	44.50	58.94	
		9	43.71	59.59	
		10	41.68	52.97	
133	2.2.98	1	37.77	55.82	55.60
		2	39.87	51.73	53.43
		3	42.15	51.87	53.05
		4	39.14	50.81	56.00
		5	42.33	54.57	
		6	40.36	51.84	
		7	41.31	52.91	
		8	38.20	54.62	
		9	44.01	58.92	
		10	42.94	56.32	
147	16.2.98	1	37.71	50.46	43.37
		2	36.35	51.15	46.31
		3	45.53	48.45	47.24
		4	39.14	51.49	47.88
		5	38.06	41.13	
		6	38.83	49.97	
		7	39.28	46.83	
		8	40.04	51.79	
		9	39.73	47.61	
		10	40.11	47.80	

Trial days	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
93	24.2.99	1	48.86	56.88	52.95
		2	46.24	55.75	50.56
		3	44.27	52.41	52.05
		4	47.29	54.93	54.39
		5	49.77	50.38	
		6	45.41	55.54	
		7	43.88	54.56	
		8	46.25	55.42	
		9	46.48	53.15	
		10	42.25	55.38	
107	10.3.99	1	43.86	49.90	53.48
		2	44.27	52.85	50.26
		3	40.58	54.64	48.82
		4	43.41	53.42	52.71
		5	42.39	51.59	
		6	40.67	51.58	
		7	40.19	54.82	
		8	44.79	53.32	
		9	40.96	52.72	
		10	41.64	48.48	
121	24.3.99	1	36.60	54.40	48.25
		2	42.51	51.20	48.25
		3	39.19	53.01	47.57
		4	35.82	52.14	52.40
		5	43.39	49.43	
		6	45.28	50.72	
		7	44.88	49.70	
		8	42.76	52.03	
		9	41.97	52.83	
		10	43.40	53.09	

Day	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
1	23.9.97	1	4.44	8.25	9.42
		2	5.33	8.74	9.85
		3	4.70	8.10	10.15
		4	4.37	8.46	8.75
		5	5.12	8.58	9.18
		6	4.89	7.74	
		7	5.36	7.60	
		8	5.06	7.78	
		9	4.98	8.63	
		10	5.12	8.42	
14	6.10.97	1	4.96	9.39	10.56
		2	5.47	10.00	10.54
		3	6.14	9.78	11.76
		4	6.27	9.09	11.13
		5	4.95	9.44	
		6	5.56	9.83	
		7	5.41	9.59	
		8	5.88	10.37	
		9	5.80	10.16	
		10	4.92	9.63	
28	20.10.97	1	5.68	9.98	11.91
		2	5.45	10.31	11.62
		3	6.24	11.34	11.41
		4	5.41	9.61	10.34
		5	5.45	10.05	
		6	5.05	9.85	
		7	5.71	9.54	
		8	5.99	9.70	
		9	6.22	10.56	
		10	5.03	9.54	
42	3.11.97	1	7.12	11.89	11.44
		2	5.92	11.43	10.98
		3	5.05	10.59	11.43
		4	6.51	11.84	11.12
		5	6.16	11.61	
		6	5.59	10.88	
		7	6.46	11.65	
		8	5.29	10.54	
		9	5.82	11.67	
		10	5.53	11.37	
56	17.11.97	1	7.67	13.10	12.54
		2	7.27	12.54	11.88
		3	7.28	12.48	12.37
		4	6.60	11.98	13.17
		5	7.04	12.82	
		6	6.27	12.71	
		7	6.68	12.02	
		8	7.01	11.94	
		9	7.37	11.81	
		10	6.33	12.17	
70	1.12.97	1	9.72	12.97	13.94
		2	9.79	12.49	12.92
		3	8.90	13.81	13.41
		4	9.15	13.46	12.23
		5	9.83	12.64	
		6	10.20	12.92	
		7	10.26	12.76	
		8	10.69	13.08	
		9	8.92	13.54	
		10	9.01	12.49	

Day	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
2	25.11.98	1	5.52	7.49	9.10
		2	6.64	6.85	8.73
		3	5.68	7.32	9.24
		4	5.81	6.55	8.58
		5	5.45	6.26	
		6	6.04	6.93	
		7	6.50	6.18	
		8	6.16	5.84	
		9	5.79	7.69	
		10	5.79	7.54	
16	9.12.98	1	6.80	7.03	11.06
		2	7.43	8.67	10.49
		3	6.42	7.59	11.09
		4	8.22	8.38	9.49
		5	8.29	7.05	
		6	7.30	7.62	
		7	6.29	7.77	
		8	7.05	6.71	
		9	7.52	7.79	
		10	6.87	8.02	
30	23.12.98	1	9.01	10.51	11.47
		2	8.66	11.16	11.81
		3	8.89	11.09	11.24
		4	8.51	10.59	10.42
		5	9.28	9.81	
		6	9.22	10.53	
		7	8.01	10.24	
		8	8.08	10.39	
		9	9.17	9.76	
		10	8.09	9.75	
44	6.1.99	1	8.58	10.90	12.20
		2	9.88	10.87	10.93
		3	10.10	10.85	11.16
		4	8.75	11.02	10.48
		5	7.80	10.62	
		6	8.81	10.58	
		7	9.20	11.79	
		8	7.84	11.49	
		9	8.04	10.76	
		10	9.71	11.39	
58	20.1.99	1	8.24	12.91	11.21
		2	7.89	13.79	12.15
		3	8.44	12.24	11.83
		4	8.91	11.85	12.11
		5	8.59	12.32	
		6	9.12	12.02	
		7	8.71	12.85	
		8	9.03	13.72	
		9	9.76	12.42	
		10	8.52	12.87	
72	3.2.99	1	6.47	14.30	12.62
		2	7.17	14.89	12.78
		3	7.89	14.75	13.16
		4	7.23	13.82	12.87
		5	7.53	14.49	
		6	7.05	14.54	
		7	8.06	13.96	
		8	7.32	15.45	
		9	7.59	13.31	
		10	7.36	14.71	

Day	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
84	15.12.97	1	12.26	13.01	13.36
		2	10.15	11.40	14.29
		3	11.17	11.27	13.34
		4	10.35	12.37	13.85
		5	11.08	12.29	
		6	10.64	12.26	
		7	11.43	11.94	
		8	12.07	11.69	
		9	10.71	12.26	
		10	10.77	11.95	
105	5.1.98	1	8.87	10.93	14.08
		2	9.62	12.30	13.23
		3	7.90	10.75	13.64
		4	8.46	11.50	13.79
		5	7.28	10.53	
		6	9.36	10.76	
		7	7.58	11.66	
		8	8.92	11.08	
		9	8.34	10.72	
		10	8.56	10.57	
119	19.1.98	1	7.65	10.75	11.27
		2	6.98	11.36	10.60
		3	7.82	11.59	12.77
		4	8.40	11.14	12.65
		5	7.85	11.76	
		6	7.48	11.12	
		7	7.83	9.95	
		8	8.11	12.03	
		9	7.84	11.73	
		10	8.26	11.06	
133	2.2.98	1	5.41	10.51	9.27
		2	4.64	10.72	10.78
		3	5.33	11.70	9.89
		4	6.16	10.26	10.55
		5	4.36	10.66	
		6	5.33	11.90	
		7	5.08	11.50	
		8	4.69	10.95	
		9	5.34	11.79	
		10	4.69	11.03	
147	16.2.98	1	8.56		
		2	6.56		
		3	7.12		
		4	7.55		
		5	7.95		
		6	7.58		
		7	6.76		
		8	6.84		
		9	7.66		
		10	7.64		

Day	Date	No.	Veld	Kikuyu HSR	Kikuyu LSR
93	24.2.99	1	5.74	14.72	9.81
		2	6.32	14.78	9.71
		3	7.02	14.57	10.21
		4	5.82	14.45	9.63
		5	5.64	13.46	
		6	6.19	13.81	
		7	6.55	13.23	
		8	6.66	14.65	
		9	6.24	14.13	
		10	6.13	13.54	
107	10.3.99	1	4.53	9.20	8.48
		2	4.17	9.80	8.16
		3	4.60	9.88	8.98
		4	6.62	9.06	7.92
		5	4.63	9.18	
		6	5.25	9.28	
		7	5.22	9.25	
		8	4.64	9.73	
		9	4.55	9.16	
		10	5.57	9.68	
121	24.3.99	1	5.94	10.06	8.90
		2	4.21	9.84	9.51
		3	4.76	10.28	8.60
		4	4.31	8.93	7.94
		5	3.71	10.30	
		6	5.15	9.72	
		7	3.71	9.69	
		8	5.51	9.97	
		9	5.03	10.14	
		10	4.97	9.80	

Appendix 7 - Cattle production data for Season 1 (1997 - 1998)

Grazing	Treatment	Implant	Number	Initial Mass	Final Mass	Gain	ADG	Carcass Mass	R / kg
Veld	Grass	x	23	174	262	88	0.58	138	7.38
Veld	Grass	x	28	208	294	86	0.57	203	7.86
Veld	Grass	I	57	222	334	112	0.74	153	7.40
Veld	Grass	I	19	186	274	88	0.58	121	7.20
Veld	Grass	I	22	216	308	92	0.61	139	8.09
Veld	Standard	x	30	228	346	118	0.78	168	8.23
Veld	Standard	x	38	180	300	120	0.79	164	8.42
Veld	Standard	I	152	178	332	154	1.01	184	8.42
Veld	Standard	I	169	240	444	204	1.34	218	8.23
Veld	Standard	I	144	268	408	140	0.92	159	8.42
Veld	Nat Protein	x	25	218	348	130	0.86	163	6.90
Veld	Nat Protein	x	156	188	290	102	0.67	138	7.96
Veld	Nat Protein	I	6	186	338	152	1.00	177	8.60
Veld	Nat Protein	I	31	206	352	146	0.96	124	7.48
Veld	Nat Protein	I	143	250	428	178	1.17	216	8.65
Veld	Avoparcin	x	185	188	322	134	0.88	156	8.54
Veld	Avoparcin	x	43	268	388	120	0.79	191	8.60
Veld	Avoparcin	I	15	196	332	136	0.89	167	7.50
Veld	Avoparcin	I	184	222	377	155	1.02	152	7.28
Veld	Avoparcin	I	14	234	366	132	0.87	160	7.70
Veld	Bentonite	x	109	262	360	98	0.64	210	8.42
Veld	Bentonite	x	26	184	278	94	0.62	142	8.23
Veld	Bentonite	I	24	206	312	106	0.70	157	8.48
Veld	Bentonite	I	18	224	364	140	0.92	210	8.42
Veld	Bentonite	I	45	176	290	114	0.75	132	7.89
Kikuyu HSR	Grass	x	48	156	254	98	0.64	176	8.13
Kikuyu HSR	Grass	x	27	164	254	90	0.59	118	7.99
Kikuyu HSR	Grass	x	1	218	314	96	0.63	154	8.01
Kikuyu HSR	Grass	I	37	200	312	112	0.74	155	7.59
Kikuyu HSR	Grass	I	200	196	298	102	0.67	146	8.47
Kikuyu HSR	Grass	I	20	242	366	124	0.82	188	8.14
Kikuyu HSR	Standard	x	39	210	308	98	0.64	160	8.58
Kikuyu HSR	Standard	x	5	164	282	118	0.78	134	8.35
Kikuyu HSR	Standard	x	17	218	352	134	0.88	163	7.70
Kikuyu HSR	Standard	I	139	176	346	170	1.12	172	8.13
Kikuyu HSR	Standard	I	12	194	338	144	0.95	139	6.69
Kikuyu HSR	Standard	I	44	212	374	162	1.07	191	8.23
Kikuyu HSR	Natural Protein	x	34	246	368	122	0.80	187	8.14
Kikuyu HSR	Natural Protein	x	46	152	250	98	0.64	135	6.99
Kikuyu HSR	Natural Protein	x	33	194	334	140	0.92	168	8.65
Kikuyu HSR	Natural Protein	I	174	210	412	202	1.33	216	8.65
Kikuyu HSR	Natural Protein	I	9	218	378	160	1.05	182	8.23
Kikuyu HSR	Natural Protein	I	16	178	344	166	1.09	165	8.23
Kikuyu HSR	Avoparcin	x	7	170	278	108	0.71	216	7.86
Kikuyu HSR	Avoparcin	x	32	198	304	106	0.70	177	8.42
Kikuyu HSR	Avoparcin	x	36	184	326	142	0.93	190	7.50
Kikuyu HSR	Avoparcin	I	47	214	358	144	0.95	190	8.60
Kikuyu HSR	Avoparcin	I	10	184	374	190	1.25	182	8.23
Kikuyu HSR	Avoparcin	I	56	236	404	168	1.11	181	7.29
Kikuyu HSR	Bentonite	x	129	264	398	134	0.88	199	8.60
Kikuyu HSR	Bentonite	x	188	178	304	126	0.83	210	8.42
Kikuyu HSR	Bentonite	x	41	244	362	118	0.78	151	7.55
Kikuyu HSR	Bentonite	I	3	198	346	148	0.97	172	8.23
Kikuyu HSR	Bentonite	I	40	182	340	158	1.04	167	8.23
Kikuyu HSR	Bentonite	I	49	194	350	156	1.03	170	8.11
Kikuyu LSR	Grass	x	55	218	318	100	0.66	167	8.62
Kikuyu LSR	Grass	I	177	248	384	136	0.89	185	8.65
Kikuyu LSR	Standard	x	35	246	374	128	0.84	195	8.14
Kikuyu LSR	Standard	I	24	268	422	154	1.01	124	6.79
Kikuyu LSR	Natural Protein	x	54	224	360	136	0.89	182	8.23
Kikuyu LSR	Natural Protein	I	50	234	398	164	1.08	178	7.86
Kikuyu LSR	Avoparcin	x	4	226	338	112	0.74	179	8.60
Kikuyu LSR	Avoparcin	I	125	252	424	172	1.13	195	7.28
Kikuyu LSR	Bentonite	x	8	244	366	122	0.80	186	6.96
Kikuyu LSR	Bentonite	I	111	246	404	158	1.04	204	8.36
Overall Averages (kg or R) :				210.89	342.51	131.62	0.87	170.63	8.03

Appendix 8 - Cattle production for season 1998 - 99

Grazing	Treatment	Implant	Number	Initial Mass	Final Mass	Gain	ADG	Carcass Mass	R / kg
Veld	Grass	x	29	260	348	88	0.73	175	8.80
Veld	Grass	x	21	232	324	92	0.77	202	9.00
Veld	Grass	x	35	224	302	78	0.65	152	8.80
Veld	Grass	I	48	160	248	88	0.73	120	7.80
Veld	Grass	I	50	216	306	90	0.75	141	7.79
Veld	Standard	x	65	192	292	100	0.83	142	6.00
Veld	Standard	x	2	216	328	112	0.93	154	7.80
Veld	Standard	I	25	224	378	154	1.28	161	8.80
Veld	Standard	I	34	200	316	116	0.97	161	7.65
Veld	Standard	I	28	224	370	146	1.22	182	9.00
Veld	Natural Protein	x	6	254	302	48	0.40	138	7.80
Veld	Natural Protein	x	63	202	231	29	0.24	152	8.80
Veld	Natural Protein	I	40	188	306	118	0.98	145	8.80
Veld	Natural Protein	I	43	198	360	162	1.35	185	9.00
Veld	Avoparcin	x	45	180	312	132	1.10	153	7.80
Veld	Avoparcin	x	37	196	302	106	0.88	148	8.80
Veld	Avoparcin	I	12	244	396	152	1.27	188	9.00
Veld	Avoparcin	I	16	234	380	146	1.22	201	9.00
Veld	Avoparcin	I	32	228	360	132	1.10	184	9.00
Veld	Bentonite	x	15	200	281	81	0.68	130	7.80
Veld	Bentonite	x	58	194	300	106	0.88	149	7.80
Veld	Bentonite	I	23	246	400	154	1.28	187	9.00
Veld	Bentonite	I	8	236	338	102	0.85	171	7.80
Veld	Bentonite	I	9	234	336	102	0.85	162	7.80
Kikuyu HSR	Grass	x	11	214	334	120	1.00	137	9.00
Kikuyu HSR	Grass	x	44	202	293	91	0.76	142	9.00
Kikuyu HSR	Grass	x	17	252	364	112	0.93	153	8.00
Kikuyu HSR	Grass	I	49	206	318	112	0.93	158	6.20
Kikuyu HSR	Grass	I	4	296	406	110	0.92	196	6.20
Kikuyu HSR	Grass	I	42	200	302	102	0.85	173	8.00
Kikuyu HSR	Standard	x	41	214	310	96	0.80	149	9.00
Kikuyu HSR	Standard	x	5	206	312	106	0.88	174	9.00
Kikuyu HSR	Standard	x	27	238	354	116	0.97	171	6.80
Kikuyu HSR	Standard	I	52	198	332	134	1.12	184	9.00
Kikuyu HSR	Standard	I	46	230	382	152	1.27	213	8.20
Kikuyu HSR	Standard	I	62	206	406	**200**	1.67	176	9.00
Kikuyu HSR	Natural Protein	x	30	226	352	126	1.05	123	8.00
Kikuyu HSR	Natural Protein	x	13	252	374	122	1.02	176	9.00
Kikuyu HSR	Natural Protein	x	47	212	330	118	0.98	161	9.00
Kikuyu HSR	Natural Protein	I	59	174	284	110	0.92	146	9.00
Kikuyu HSR	Natural Protein	I	36	188	314	126	1.05	148	9.00
Kikuyu HSR	Natural Protein	I	26	238	354	116	0.97	161	8.00
Kikuyu HSR	Avoparcin	x	51	238	304	**66**	**0.55**	137	8.00
Kikuyu HSR	Avoparcin	x	55	200	356	156	1.30	145	8.00
Kikuyu HSR	Avoparcin	x	31	268	392	124	1.03	158	8.00
Kikuyu HSR	Avoparcin	I	24	214	364	150	1.25	185	7.57
Kikuyu HSR	Avoparcin	I	54	208	332	124	1.03	171	9.00
Kikuyu HSR	Avoparcin	I	18	228	362	134	1.12	191	8.20
Kikuyu HSR	Bentonite	x	33	274	370	96	0.80	173	9.00
Kikuyu HSR	Bentonite	x	39	206	320	114	0.95	151	8.00
Kikuyu HSR	Bentonite	x	3	238	364	126	1.05	159	8.00
Kikuyu HSR	Bentonite	I	19	250	382	132	1.10	187	9.20
Kikuyu HSR	Bentonite	I	1	308	456	148	1.23	217	6.20
Kikuyu HSR	Bentonite	I	22	200	248	**48**	**0.40**	179	9.00
Kikuyu LSR	Standard	x	20	218	350	132	1.10	155	8.00
Kikuyu LSR	Standard	I	60	206	344	138	1.15	179	8.00
Kikuyu LSR	Natural Protein	x	38	196	294	98	0.82	126	6.20
Kikuyu LSR	Natural Protein	I	53	222	396	174	1.45	182	6.20
Kikuyu LSR	Avoparcin	I	10	202	322	120	1.00	155	9.00
Kikuyu LSR	Avoparcin	I	57	244	386	142	1.18	160	9.00
Kikuyu LSR	Bentonite	x	14	208	316	108	0.90	149	9.00
Kikuyu LSR	Bentonite	I	56	196	324	128	1.07	153	9.00
Overall Averages (kg or R) :				219.54	337.84	118.30	0.99	163.30	8.25

Appendix 9(a) Gross Margin Analyses for Season 1(1997 - 1998)

	Cost per unit	Veld										Kikuyı	
	Unit	Grass	Standard	Nat.Protein	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Nat.Protein
Supplement Price (R/kg)		0.00	0.86	0.86	0.88	0.85	0.00	0.86	0.86	0.88	0.85	0.00	0.86
Supplement cost	per AU	0.00	185.42	185.42	189.73	183.26	0.00	185.42	185.42	189.73	183.26	0.00	185.42
Fertiliser cost	per Ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1460.05	1460.05
Start Mass	kg	382.00	408.00	406.00	456.00	446.00	624.00	686.00	642.00	652.00	606.00	538.00	592.00
	per AU	191.00	204.00	203.00	228.00	223.00	208.00	228.67	214.00	217.33	202.00	179.33	197.33
Animal Number		2.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Area	ha	7.97	4.27	8.42	6.52	7.86	7.97	4.27	8.42	6.52	7.86	0.38	0.38
Total animal number		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.00	3.00
Stocking Rate	(AU.ha-1)	0.63	1.17	0.59	0.77	0.64	0.63	1.17	0.59	0.77	0.64	7.89	7.89
Sale price	R	2614.02	2773.52	2223.18	2974.84	2936.86	3127.91	4682.20	4318.12	3904.10	4141.04	3607.24	3919.03
Per Animal													
Implant cost	per AU	0.00	0.00	0.00	0.00	0.00	8.33	8.33	8.33	8.33	8.33	0.00	0.00
Purchase price	per AU	955.00	1020.00	1015.00	1140.00	1115.00	1040.00	1143.33	1070.00	1086.67	1010.00	896.67	986.67
Supplement cost	per AU	0.00	185.42	185.42	189.73	183.26	0.00	185.42	185.42	189.73	183.26	0.00	185.42
Fertilizer cost	per AU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	184.94	184.94
Total costs	per AU	955.00	1205.42	1200.42	1329.73	1298.26	1048.33	1337.08	1263.75	1284.72	1201.59	1081.61	1357.02
Total income	per AU	1307.01	1386.76	1111.59	1487.42	1468.43	1042.64	1560.73	1439.37	1301.37	1380.35	1202.41	1306.34
Gross margin	per AU	352.01	181.34	-88.83	157.69	170.17	-5.69	223.65	175.63	16.64	178.76	120.81	-50.68
Per Hectare													
Implant cost	per AU	0.00	0.00	0.00	0.00	0.00	5.23	9.75	4.95	6.39	5.30	0.00	0.00
Purchase price	per AU	599.12	1194.38	602.73	874.23	709.29	652.45	1338.80	635.39	833.33	642.49	7078.95	7789.47
Supplement cost	per AU	0.00	217.11	110.10	145.50	116.58	0.00	217.11	110.10	145.50	116.58	0.00	1463.81
Fertilizer cost	per AU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1460.05	1460.05
Total costs	per AU	599.12	1411.49	712.84	1019.73	825.87	657.67	1565.67	750.44	985.22	764.37	8539.00	10713.33
Total income	per AU	819.96	1623.84	660.09	1140.66	934.12	654.10	1827.56	854.73	997.98	878.08	9492.74	10313.24
Gross margin	per AU	220.83	212.35	-52.75	120.93	108.25	-3.57	261.89	104.29	12.76	113.71	953.74	-400.10

ı HSR				Kikuyu HSR								Kikuyu LSR				
Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Protein	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*
0.88	0.85	0.00	0.86	0.86	0.88	0.85	0.00	0.86	0.86	0.88	0.85	0.00	0.86	0.86	0.88	0.85
189.73	183.26	0.00	185.42	185.42	189.73	183.26	0.00	185.42	185.42	189.73	183.26	0.00	185.42	185.42	189.73	183.26
1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05
552.00	686.00	638.00	582.00	606.00	634.00	574.00	218.00	246.00	224.00	226.00	244.00	248.00	268.00	234.00	252.00	246.00
184.00	228.67	212.67	194.00	202.00	211.33	191.33	218.00	246.00	224.00	226.00	244.00	248.00	268.00	234.00	252.00	246.00
3.00	3.00	3.00	3.00	3.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
7.89	7.89	7.89	7.89	7.89	7.89	7.89	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
4621.10	4619.65	3943.39	3900.20	4684.21	4451.35	4168.67	1439.54	1587.30	1497.86	1539.40	1294.56	1600.25	841.96	1399.08	1419.60	1722.00
0.00	0.00	8.33	8.33	8.33	8.33	8.33	0.00	0.00	0.00	0.00	0.00	8.33	8.33	8.33	8.33	8.33
920.00	1143.33	1063.33	970.00	1010.00	1056.67	956.67	1090.00	1230.00	1120.00	1130.00	1220.00	1240.00	1340.00	1170.00	1260.00	1230.00
189.73	183.26	0.00	185.42	185.42	189.73	183.26	0.00	185.42	185.42	189.73	183.26	0.00	185.42	185.42	189.73	183.26
184.94	184.94	184.94	184.94	184.94	184.94	184.94	582.56	582.56	582.56	582.56	582.56	582.56	582.56	582.56	582.56	582.56
1294.67	1511.53	1256.60	1348.69	1388.69	1439.66	1333.20	1672.56	1997.98	1887.98	1902.29	1985.82	1830.89	2116.31	1946.31	2040.62	2004.15
1540.37	1539.88	1314.46	1300.07	1561.40	1483.78	1389.56	1439.54	1587.30	1497.86	1539.40	1294.56	1600.25	841.96	1399.08	1419.60	1722.00
245.70	28.35	57.86	-48.62	172.72	44.12	56.36	-233.02	-410.68	-390.12	-362.89	-691.26	-230.64	-1274.35	-547.23	-621.02	-282.15
0.00	0.00	65.76	65.76	65.76	65.76	65.76	0.00	0.00	0.00	0.00	0.00	20.88	20.88	20.88	20.88	20.88
7263.16	9026.32	8394.74	7657.89	7973.68	8342.11	7552.63	2731.83	3082.71	2807.02	2832.08	3057.64	3107.77	3358.40	2932.33	3157.89	3082.71
1497.85	1446.79	0.00	1463.81	1463.81	1497.85	1446.79	0.00	464.70	464.70	475.51	459.30	0.00	464.70	464.70	475.51	459.30
1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05
10221.06	11933.16	9920.55	10647.52	10963.31	11365.77	10525.23	4191.88	5007.46	4731.77	4767.64	4976.99	4588.70	5304.02	4877.96	5114.33	5022.93
12160.79	12156.97	10377.34	10263.68	12326.87	11714.08	10970.18	3607.87	3978.20	3754.04	3858.15	3244.51	4010.65	2110.18	3506.47	3557.89	4315.79
1939.73	223.82	456.79	-383.83	1363.56	348.31	444.95	-584.01	-1029.26	-977.73	-909.49	-1732.48	-578.04	-3193.85	-1371.49	-1556.44	-707.14

Appendix 9 (contd.) - Gross Margin Analysis (1998 - 1999; 121 days)

		Cost per unit	Veld										Kikuyu	
			Grass	Supermol	Nat.Protein	Avoparcin	Bentonite	*Grass*	*Supermol*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Nat.Protein
	Supplement Price (R/kg)		0.00	0.86	0.86	0.88	0.85	0.00	0.86	0.86	0.88	0.85	0.00	0.86
	Supplement cost	per AU	0.00	145.68	145.68	149.07	143.99	0.00	145.68	145.68	149.07	143.99	0.00	145.68
	Fertiliser cost	per Ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1460.05	1460.05
	Start Mass	kg	716.00	408.00	456.00	376.00	394.00	376.00	448.00	386.00	706.00	716.00	668.00	690.00
		per AU	238.67	204.00	228.00	188.00	197.00	188.00	149.33	193.00	235.33	238.67	222.67	230.00
	Animal Number		3.00	2.00	2.00	2.00	2.00	2.00	3.00	2.00	3.00	3.00	3.00	3.00
	Area	ha	7.97	4.27	8.42	6.52	7.86	7.97	4.27	8.42	6.52	7.86	0.38	0.38
	Total animal number		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.00	3.00
	Stocking Rate	(AU.ha-1)	0.63	1.17	0.59	0.77	0.64	0.63	1.17	0.59	0.77	0.64	7.89	7.89
	Sale price	R	4695.00	2053.00	2413.00	2495.00	2176.00	2035.00	4285.00	2941.00	5157.00	4279.00	3735.00	4017.00
Per Animal	Implant cost	per AU	0.00	0.00	0.00	0.00	0.00	8.33	8.33	8.33	8.33	8.33	0.00	0.00
	Purchase price	per AU	1193.33	1020.00	1140.00	940.00	985.00	940.00	746.67	965.00	1176.67	1193.33	1113.33	1150.00
	Supplement cost	per AU	0.00	145.68	145.68	149.07	143.99	0.00	145.68	145.68	149.07	143.99	0.00	145.68
	Fertilizer cost	per AU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	184.94	184.94
	Total costs	per AU	1193.33	1165.68	1285.68	1089.07	1128.99	948.33	900.68	1119.01	1334.07	1345.65	1298.27	1480.62
	Total income	per AU	1565.00	1026.50	1206.50	1247.50	1088.00	1017.50	1428.33	1470.50	1719.00	1426.33	1245.00	1339.00
	Gross margin	per AU	371.67	-139.18	-79.18	158.43	-40.99	69.17	527.65	351.49	384.93	80.68	-53.27	-141.62
Per Hectare	Implant cost	per AU	0.00	0.00	0.00	0.00	0.00	5.23	9.75	4.95	6.39	5.30	0.00	0.00
	Purchase price	per AU	748.64	1194.38	676.96	720.86	626.59	589.71	874.32	573.04	902.35	759.12	8789.47	9078.95
	Supplement cost	per AU	0.00	170.59	86.51	114.32	91.60	0.00	170.59	86.51	114.32	91.60	0.00	1150.14
	Fertilizer cost	per AU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1460.05	1460.05
	Total costs	per AU	748.64	1364.97	763.47	835.18	718.19	594.94	1054.66	664.50	1023.06	856.01	10249.52	11689.13
	Total income	per AU	981.81	1201.99	716.45	956.67	692.11	638.33	1672.52	873.22	1318.25	907.34	9828.95	10571.05
	Gross margin	per AU	233.17	-162.98	-47.02	121.49	-26.08	43.39	617.86	208.72	295.19	51.32	-420.58	-1118.08

ɹ HSR		Kikuyu HSR										Kikuyu LSR				
Avoparcin	Bentonite	*Grass*	*Supermol*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Supermol	Nat.Protein	Avoparcin	Bentonite	*Grass*	*Supermol*	*Nat.Protein*	*Avoparcin*	*Bentonite*
0.88	0.85	0.00	0.86	0.86	0.88	0.85	0.00	0.86	0.86	0.88	0.85	0.00	0.86	0.86	0.88	0.85
149.07	143.99	0.00	145.68	145.68	149.07	143.99	0.00	145.68	145.68	149.07	143.99	0.00	145.68	145.68	149.07	143.99
1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	0.00	1460.05	1460.05	1460.05	1460.05	0.00	1460.05	1460.05	1460.05	1460.05
706.00	718.00	702.00	634.00	600.00	650.00	750.00	0.00	218.00	196.00	202.00	208.00	0.00	206.00	222.00	244.00	196.00
235.33	239.33	234.00	211.33	200.00	216.67	250.00	0.00	218.00	196.00	202.00	208.00	0.00	206.00	222.00	244.00	196.00
3.00	3.00	3.00	3.00	3.00	3.00	3.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.00	0.80	0.80	0.80	0.80	0.00	0.80	0.80	0.80	0.80
3.00	3.00	3.00	3.00	3.00	3.00	3.00	0.00	2.00	2.00	2.00	2.00	0.00	2.00	2.00	2.00	2.00
7.89	7.89	7.89	7.89	7.89	7.89	7.89	0.00	2.51	2.51	2.51	2.51	0.00	2.51	2.51	2.51	2.51
3520.00	4037.00	3578.00	4986.00	3934.00	4505.00	4676.00	0.00	1240.00	781.00	1395.00	1341.00	0.00	1432.00	1128.00	1440.00	1377.00
0.00	0.00	8.33	8.33	8.33	8.33	8.33	0.00	0.00	0.00	0.00	0.00	0.00	8.33	8.33	8.33	8.33
1176.67	1196.67	1170.00	1056.67	1000.00	1083.33	1250.00	0.00	1090.00	980.00	1010.00	1040.00	0.00	1030.00	1110.00	1220.00	980.00
149.07	143.99	0.00	145.68	145.68	149.07	143.99	0.00	145.68	145.68	149.07	143.99	0.00	145.68	145.68	149.07	143.99
184.94	184.94	184.94	184.94	184.94	184.94	184.94	0.00	582.56	582.56	582.56	582.56	0.00	582.56	582.56	582.56	582.56
1510.68	1525.60	1363.27	1395.62	1338.95	1425.68	1587.26	0.00	1818.24	1708.24	1741.63	1766.55	0.00	1766.57	1846.57	1959.96	1714.88
1173.33	1345.67	1192.67	1662.00	1311.33	1501.67	1558.67	0.00	1240.00	781.00	1395.00	1341.00	0.00	1432.00	1128.00	1440.00	1377.00
-337.35	-179.93	-170.60	266.38	-27.62	75.99	-28.59	0.00	-578.24	-927.24	-346.63	-425.55	0.00	-334.57	-718.57	-519.96	-337.88
0.00	0.00	65.76	65.76	65.76	65.76	65.76	0.00	0.00	0.00	0.00	0.00	0.00	20.88	20.88	20.88	20.88
9289.47	9447.37	9236.84	8342.11	7894.74	8552.63	9868.42	0.00	2731.83	2456.14	2531.33	2606.52	0.00	2581.45	2781.95	3057.64	2456.14
1176.88	1136.76	0.00	1150.14	1150.14	1176.88	1136.76	0.00	365.12	365.12	373.61	360.88	0.00	365.12	365.12	373.61	360.88
1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	1460.05	0.00	1460.05	1460.05	1460.05	1460.05	0.00	1460.05	1460.05	1460.05	1460.05
11926.41	12044.18	10762.66	11018.06	10570.69	11255.33	12531.00	0.00	4557.00	4281.31	4364.99	4427.44	0.00	4427.50	4628.00	4912.19	4297.94
9263.16	10623.68	9415.79	13121.05	10352.63	11855.26	12305.26	0.00	3107.77	1957.39	3496.24	3360.90	0.00	3588.97	2827.07	3609.02	3451.13
-2663.25	-1420.50	-1346.87	2103.00	-218.06	599.93	-225.73	0.00	-1449.23	-2323.92	-868.75	-1066.54	0.00	-838.53	-1800.94	-1303.16	-846.82

Appendix 10(a) - Partial budget for Season 1 (1997 - 1998) per hectare

	Veld										Kikuy				
	Grass	Standard	Nat.Protei	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protei*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Protein	Avoparcin	Bentonite
Total cost changes	599.12	1411.49	712.84	1019.73	825.87	657.67	1565.67	750.44	985.22	764.37	8539.00	10713.33	10713.33	10221.06	11933.16
Total income changes	819.96	1623.84	660.09	1140.66	934.12	654.10	1827.56	854.73	997.98	878.08	9492.74	9860.00	10313.24	12160.79	12156.97
	220.83	212.35	-52.75	120.93	108.25	-3.57	261.89	104.29	12.76	113.71	953.74	-853.33	-400.10	1939.73	223.82

Treatment A	Treatment B Grass	Standard	Nat.Protei	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protei*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Protein	Avoparcin	Bentonite
Grass		-812.37	-113.71	-420.61	-226.74	-58.55	-966.54	-151.32	-1206.05	-165.25	-7939.88	-10114.21	-10114.21	-9621.94	-11334.03
Standard	812.37		-265.09	391.76	585.63	753.82	-154.17	661.05	426.28	647.12	-7127.50	-9301.84	-9301.84	-8809.57	-10521.66
Nat.Protein	-159.95	-698.66		-306.89	161.00	55.16	-852.83	-37.61	-272.38	-51.53	-7826.16	-10000.50	-10000.50	-9508.22	-11220.32
Avoparcin	-720.05	-1532.42	-833.77		-946.79	-778.60	-1686.60	-871.37	-1106.15	-885.30	-8659.93	-10834.26	-10834.26	-10341.99	-12054.08
Bentonite	-707.37	-1519.74	-821.09	-1127.98		-111.82	153.64	-3.96	-1093.47	5.46	845.49	-961.58	-508.35	1831.48	115.57
Grass	-595.55	-1407.92	-709.26	-1016.16	-822.29		265.46	107.86	16.33	117.28	957.31	-849.76	-396.53	1943.30	227.39
Standard	-861.01	-1673.38	-974.73	-1281.62	-1087.76	-919.56		-157.60	-249.13	-148.18	691.85	-1115.22	-661.99	1677.84	-38.07
Nat.Protein	116.54	108.05	-157.04	16.64	3.96	-107.86	157.60		-91.53	9.42	849.45	-957.63	-504.39	1835.44	119.53
Avoparcin	208.07	199.58	-65.51	108.17	95.49	-16.33	249.13	91.53		100.95	940.98	-866.10	-412.86	1926.97	211.06
Bentonite	107.12	98.63	-166.46	7.22	-5.46	-117.28	148.18	-9.42	-100.95		840.03	-967.05	-513.81	1826.02	110.11
Grass	-732.91	-741.39	-1006.49	-832.81	-845.49	-957.31	-691.85	-849.45	-940.98	-840.03		-1807.07	-1353.84	985.99	-729.92
Standard	1074.17	1065.68	800.59	974.26	961.58	849.76	1115.22	957.63	866.10	967.05	1807.07		453.24	2793.06	1077.15
Nat.Protein	620.93	612.44	347.35	521.03	508.35	396.53	661.99	504.39	412.86	513.81	1353.84	-453.24		2339.83	623.92
Avoparcin	-1718.89	-1727.38	-1992.48	-1818.80	-1831.48	-1943.30	-1677.84	-1835.44	-1926.97	-1826.02	-985.99	-2793.06	-2339.83		1715.91
Bentonite	-2.98	-11.47	-276.57	-102.89	-115.57	-227.39	38.07	-119.53	-211.06	-110.11	729.92	-1077.15	-623.92	1715.91	
Grass	-235.96	-244.45	-509.54	-335.86	-348.54	-460.36	-194.90	-352.50	-444.03	-343.08	496.95	-1310.13	-856.89	1482.94	-232.97
Standard	604.67	596.18	331.09	504.76	492.08	380.26	645.72	488.13	396.60	497.55	1337.57	-469.50	-16.26	2323.56	607.65
Nat.Protein	-12106.03	-1151.21	-1416.31	-1242.63	-1255.31	-1367.13	-1101.67	-1259.27	-1350.80	-1249.85	-409.82	-2216.89	-1763.66	576.17	-1139.74
Avoparcin	-947.43	-1759.80	-1061.14	-227.38	-240.06	-351.88	-86.42	-244.02	-335.55	-234.60	605.43	-1201.64	-748.41	1591.42	-12281.46
Bentonite	-224.12	-232.60	-497.70	-324.02	-336.70	-448.52	-183.06	-340.66	-432.19	-331.24	508.79	-1298.28	-845.05	1494.78	-221.13
Grass	804.84	796.36	531.26	704.94	692.26	580.44	845.90	688.30	596.77	697.72	1537.75	-269.32	183.91	2523.74	807.83
Standard	1250.10	1241.61	976.52	1150.19	1137.51	1025.69	1291.15	1133.55	1042.03	1142.98	1983.00	175.93	629.17	2968.99	1253.08
Nat.Protein	1198.57	1190.08	924.99	1098.66	1085.98	974.16	1239.62	1082.03	990.50	1091.45	1931.47	124.40	577.64	2917.46	1201.55
Avoparcin	1130.33	1121.84	856.75	1030.42	1017.74	905.92	1171.38	1013.79	922.26	1023.21	1863.23	56.16	509.40	2849.22	1133.31
Bentonite	1953.32	1944.83	1679.73	1853.41	1840.73	1728.91	1994.37	1836.77	1745.24	1846.19	2686.22	879.15	1332.38	3672.21	1956.30
Grass	798.88	790.39	525.30	698.97	686.30	574.47	839.93	682.34	590.81	691.76	1531.78	-275.29	177.95	2517.77	801.86
Standard	3414.68	3406.20	3141.10	3314.78	3302.10	3190.28	3455.74	3298.14	3206.61	3307.56	4147.59	2340.52	2793.75	5133.58	3417.67
Nat.Protein	1592.33	1583.84	1318.75	1492.42	1479.74	1367.92	1633.38	1475.79	1384.26	1485.21	2325.23	518.16	971.40	3311.22	1595.31
Avoparcin	1777.27	1768.78	1503.69	1677.37	1664.69	1552.86	1818.33	1660.73	1569.20	1670.15	2510.18	703.10	1156.34	3496.16	1780.25
Bentonite	927.98	919.49	654.40	828.07	815.39	703.57	969.03	811.43	719.91	820.86	1660.88	-146.19	307.05	2646.87	930.96

u HSR									Kikuyu LSR					
Grass	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Proteir	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protei*	*Avoparcin*	*Bentonite*
9920.55	10647.52	10963.31	11365.77	10525.23	4191.88	5007.46	4731.77	4767.64	4976.99	4588.70	5304.02	4877.96	5114.33	5022.93
10377.34	10263.68	12326.87	11714.08	10970.18	3607.87	3978.20	3754.04	3858.15	3244.51	4010.65	2110.18	3506.47	3557.89	4315.79
456.79	-383.83	1363.56	348.31	444.95	-584.01	-1029.26	-977.73	-909.49	-1732.48	-578.04	-3193.85	-1371.49	-1556.44	-707.14

Grass	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Proteir	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protei*	*Avoparcin*	*Bentonite*	Treatment A
-9321.43	-10048.40	-10364.19	-10766.65	-9926.11	-3592.76	-4408.34	-4132.65	-4168.52	-4377.87	-3989.57	-4704.90	-4278.84	-4515.21	-4423.81	Grass
-8509.06	-9236.02	-9551.81	-9954.28	-9113.74	-2780.39	-3595.96	-3320.28	-3356.14	-3565.50	-3177.20	-3892.53	-3466.47	-3702.84	-3611.44	Standard
-9207.71	-9934.68	-10250.47	-10652.93	-9812.40	-3479.04	-4294.62	-4018.93	-4054.80	-4264.16	-3875.86	-4591.19	-4165.12	-4401.49	-4310.10	Nat.Protein
-10041.48	-10768.45	-11084.24	-11486.70	-10646.16	-4312.81	-5128.39	-4852.70	-4888.57	-5097.92	-4709.63	-5424.95	-4998.89	-5235.26	-5143.86	Avoparcin
348.54	-492.08	1255.31	240.06	336.70	-692.26	-1137.51	-1085.98	-1017.74	-1840.73	-686.30	-3302.10	-1479.74	-1664.69	-815.39	Bentonite
460.36	-380.26	1367.13	351.88	448.52	-580.44	-1025.69	-974.16	-905.92	-1728.91	-574.47	-3190.28	-1367.92	-1552.86	-703.57	*Grass*
194.90	-645.72	1101.67	86.42	183.06	-845.90	-1291.15	-1239.62	-1171.38	-1994.37	-839.93	-3455.74	-1633.38	-1818.33	-969.03	*Standard*
352.50	-488.13	1259.27	244.02	340.66	-688.30	-1133.55	-1082.03	-1013.79	-1836.77	-682.34	-3298.14	-1475.79	-1660.73	-811.43	*Nat.Protein*
444.03	-396.60	1350.80	335.55	432.19	-596.77	-1042.03	-990.50	-922.26	-1745.24	-590.81	-3206.61	-1384.26	-1569.20	-719.91	*Avoparcin*
343.08	-497.55	1249.85	234.60	331.24	-697.72	-1142.98	-1091.45	-1023.21	-1846.19	-691.76	-3307.56	-1485.21	-1670.15	-820.86	*Bentonite*
-496.95	-1337.57	409.82	-605.43	-508.79	-1537.75	-1983.00	-1931.47	-1863.23	-2686.22	-1531.78	-4147.59	-2325.23	-2510.18	-1660.88	Grass
1310.13	469.50	2216.89	1201.64	1298.28	269.32	-175.93	-124.40	-56.16	-879.15	275.29	-2340.52	-518.16	-703.10	146.19	Standard
856.89	16.26	1763.66	748.41	845.05	-183.91	-629.17	-577.64	-509.40	-1332.38	-177.95	-2793.75	-971.40	-1156.34	-307.05	Nat.Protein
-1482.94	-2323.56	-576.17	-1591.42	-1494.78	-2523.74	-2968.99	-2917.46	-2849.22	-3672.21	-2517.77	-5133.58	-3311.22	-3496.16	-2646.87	Avoparcin
232.97	-607.65	1139.74	124.49	221.13	-807.83	-1253.08	-1201.55	-1133.31	-1956.30	-801.86	-3417.67	-1595.31	-1780.25	-930.96	Bentonite
	-840.63	906.77	-108.48	-11.84	-1040.80	-1486.06	-1434.53	-1366.29	-2189.27	-1034.84	-3650.64	-1828.29	-2013.23	-1163.93	*Grass*
840.63		1747.39	732.14	828.78	-200.18	-645.43	-593.90	-525.66	-1348.65	-194.21	-2810.02	-987.66	-1172.60	-323.31	*Standard*
-906.77	-1747.39		-1015.25	-918.61	-1947.57	-2392.82	-2341.29	-2273.05	-3096.04	-1941.61	-4557.41	-2735.05	-2920.00	-2070.70	*Nat.Protein*
-10268.86	-10995.83	1015.25		96.64	-932.32	-1377.57	-1326.04	-1257.80	-2080.79	-926.35	-3542.16	-1719.80	-1904.74	-1055.45	*Avoparcin*
11.84	-828.78	918.61	-96.64		-1028.96	-1474.21	-1422.68	-1354.44	-2177.43	-1022.99	-3638.80	-1816.44	-2001.39	-1152.09	*Bentonite*
1040.80	200.18	1947.57	932.32	1028.96		-445.25	-393.72	-325.48	-1148.47	5.96	-2609.84	-787.48	-972.43	-123.13	Grass
1486.06	645.43	2392.82	1377.57	1474.21	445.25		51.53	119.77	-703.22	451.22	-2164.59	-342.23	-527.17	322.12	Standard
1434.53	593.90	2341.29	1326.04	1422.68	393.72	-51.53		68.24	-754.75	399.69	-2216.12	-393.76	-578.70	270.59	Nat.Protein
1366.29	525.66	2273.05	1257.80	1354.44	325.48	-119.77	-68.24		-822.99	331.45	-2284.36	-462.00	-646.94	202.35	Avoparcin
2189.27	1348.65	3096.04	2080.79	2177.43	1148.47	703.22	754.75	822.99		1154.44	-1461.37	360.99	176.05	1025.34	Bentonite
1034.84	194.21	1941.61	926.35	1022.99	-5.96	-451.22	-399.69	-331.45	-1154.44		-2615.80	-793.45	-978.39	-129.10	*Grass*
3650.64	2810.02	4557.41	3542.16	3638.80	2609.84	2164.59	2216.12	2284.36	1461.37	2615.80		1822.36	1637.41	2486.71	*Standard*
1828.29	987.66	2735.05	1719.80	1816.44	787.48	342.23	393.76	462.00	-360.99	793.45	-1822.36		-184.94	664.35	*Nat.Protein*
2013.23	1172.60	2920.00	1904.74	2001.39	972.43	527.17	578.70	646.94	-176.05	978.39	-1637.41	184.94		849.29	*Avoparcin*
1163.93	323.31	2070.70	1055.45	1152.09	123.13	-322.12	-270.59	-202.35	-1025.34	129.10	-2486.71	-664.35	-849.29		*Bentonite*

Appendix 10(b) - Partial budget for Season 2 (1998 - 1999) per hectare

	Veld Grass	Standard	Nat.Protein	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Protein	Avoparcin	Bentonite
Total cost changes	748.64	1364.97	763.47	835.18	718.19	594.94	1054.66	664.50	1023.06	856.01	10249.52	11268.08	11689.13	11926.41	12044.18
Total income changes	981.81	1201.99	716.45	956.67	692.11	638.33	1672.52	873.22	1318.25	907.34	9828.95	10707.89	10571.05	9263.16	10623.68
	233.17	-162.98	-47.02	121.49	-26.08	43.39	617.86	208.72	295.19	51.32	-420.58	-560.19	-1118.08	-2663.25	-1420.50

Treatment A	Treatment B Grass	Standard	Nat.Protein	Avoparcin	Bentonite	*Grass*	*Standard*	*Nat.Protein*	*Avoparcin*	*Bentonite*	Grass	Standard	Nat.Protein	Avoparcin	Bentonite
Grass		-396.14	-280.19	-111.67	-259.24	-189.77	384.69	-24.45	62.03	-181.84	-653.74	-793.35	-1351.25	-2896.42	-1653.66
Standard	396.14		115.96	284.47	136.90	206.37	780.84	371.70	458.17	214.30	-257.60	-397.21	-955.10	-2500.27	-1257.52
Nat.Protein	14.00	-115.96		168.52	20.95	90.42	664.88	255.74	342.21	98.34	-373.55	-513.17	-1071.06	-2616.23	-1373.48
Avoparcin	111.67	-284.47	-168.52		-147.57	-78.10	496.37	87.23	173.70	-70.17	-542.07	-681.68	-1239.58	-2784.74	-1541.99
Bentonite	259.24	-136.90	-20.95	147.57		69.47	643.94	234.80	321.27	77.40	-394.50	-534.11	-1092.01	-2637.17	-1394.42
Grass	189.77	-206.37	-90.42	78.10	-69.47		574.47	165.33	251.80	7.93	-463.97	-603.58	-1161.48	-2706.64	-1463.89
Standard	-384.69	-780.84	-664.88	-496.37	-643.94	-574.47		-409.14	-322.67	-566.54	-1038.44	-1178.05	-1735.94	-3281.11	-2038.36
Nat.Protein	24.45	-371.70	-255.74	-87.23	-234.80	-165.33	409.14		86.47	-157.40	-629.30	-768.91	-1326.80	-2871.97	-1629.22
Avoparcin	-62.03	-458.17	-342.21	-173.70	-321.27	-251.80	322.67	-86.47		-243.87	-715.77	-855.38	-1413.27	-2958.44	-1715.69
Bentonite	181.84	-214.30	-98.34	70.17	-77.40	-7.93	566.54	157.40	243.87		-471.90	-611.51	-1169.40	-2714.57	-1471.82
Grass	653.74	257.60	373.55	542.07	394.50	463.97	1038.44	629.30	715.77	471.90		-139.61	-697.51	-2242.67	-999.92
Standard	793.35	397.21	513.17	681.68	534.11	603.58	1178.05	768.91	855.38	611.51	139.61		-557.89	-2103.06	-860.31
Nat.Protein	1351.25	955.10	1071.06	1239.58	1092.01	1161.48	1735.94	1326.80	1413.27	1169.40	697.51	557.89		-1545.17	-302.42
Avoparcin	2896.42	2500.27	2616.23	2784.74	2637.17	2706.64	3281.11	2871.97	2958.44	2714.57	2242.67	2103.06	1545.17		-1242.75
Bentonite	1653.66	1257.52	1373.48	1541.99	1394.42	1463.89	2038.36	1629.22	1715.69	1471.82	999.92	860.31	302.42	-1242.75	
Grass	1580.03	1183.89	1299.84	1468.36	1320.79	1390.26	1964.73	1555.59	1642.06	1398.19	926.29	786.68	228.78	-1316.38	-73.63
Standard	-1869.83	-2265.98	-2150.02	-1981.50	-2129.07	-2059.60	-1485.14	-1894.28	-1807.80	-2051.67	-2523.57	-2663.18	-3221.08	-4766.25	-3523.49
Nat.Protein	-10119.47	55.08	171.03	339.55	191.98	261.45	835.92	426.78	513.25	269.38	-202.52	-342.13	-900.03	-2445.19	-1202.44
Avoparcin	-366.77	-762.91	-646.96	-478.44	-626.01	-556.54	17.93	-391.21	-304.74	-548.61	-1020.51	-1160.12	-1718.02	-3263.18	-2020.43
Bentonite	458.90	62.76	178.71	347.23	199.66	269.13	843.59	434.46	520.93	277.06	-194.84	-334.45	-892.35	-2437.52	-1194.76
Grass	233.17	-162.98	-47.02	121.49	-26.08	43.39	617.86	208.72	295.19	51.32	-420.58	-560.19	-1118.08	-2663.25	-1420.50
Standard	1682.40	1286.25	1402.21	1570.73	1423.16	1492.63	2067.09	1657.95	1744.43	1500.56	1028.66	889.05	331.15	-1214.02	28.74
Nat.Protein	2557.09	2160.94	2276.90	2445.41	2297.84	2367.31	2941.78	2532.64	2619.11	2375.24	1903.34	1763.73	1205.84	-339.33	903.42
Avoparcin	1101.92	705.77	821.73	990.25	842.68	912.15	1486.61	1077.47	1163.94	920.07	448.18	308.56	-249.33	-1794.50	-551.75
Bentonite	1299.71	903.56	1019.52	1188.04	1040.47	1109.94	1684.40	1275.26	1361.73	1117.86	645.96	506.35	-51.54	-1596.71	-353.96
Grass	233.17	-162.98	-47.02	121.49	-26.08	43.39	617.86	208.72	295.19	51.32	-420.58	-560.19	-1118.08	-2663.25	-1420.50
Standard	1071.70	675.55	791.51	960.03	812.46	881.93	1456.39	1047.25	1133.72	889.85	417.95	278.34	-279.55	-1824.72	-581.97
Nat.Protein	2034.10	1637.96	1753.92	1922.43	1774.86	1844.33	2418.80	2009.66	2096.13	1852.26	1380.36	1240.75	682.86	-862.31	380.44
Avoparcin	1536.33	1140.18	1256.14	1424.66	1277.09	1346.56	1921.02	1511.88	1598.36	1354.49	882.59	742.98	185.08	-1360.09	-117.33
Bentonite	1079.98	683.84	799.80	968.31	820.74	890.21	1464.68	1055.54	1142.01	898.14	426.24	286.63	-271.26	-1816.43	-573.68

Grass	Standard	Nat.Protein	Avoparcin	Bentonite	Grass	Standard	Nat.Protein	Avoparcin	Bentonite	Grass	Standard	Nat.Protein	Avoparcin	Bentonite
10762.66	11018.06	10570.69	11255.33	12531.00	0.00	4557.00	4281.31	4364.99	4427.44	0.00	4427.50	4628.00	4912.19	4297.94
9415.79	13121.05	10352.63	11855.26	12305.26	0.00	3107.77	1957.39	3496.24	3360.90	0.00	3588.97	2827.07	3609.02	3451.13
-1346.87	2103.00	-218.06	599.93	-225.73	0.00	-1449.23	-2323.92	-868.75	-1066.54	0.00	-838.53	-1800.94	-1303.16	-846.82

Grass	Standard	Nat.Protein	Avoparcin	Bentonite	Grass	Standard	Nat.Protein	Avoparcin	Bentonite	Grass	Standard	Nat.Protein	Avoparcin	Bentonite	Treatment A
-1580.03	1869.83	-451.22	366.77	-458.90		-1682.40	-2557.09	-1101.92	-1299.71		-1071.70	-2034.10	-1536.33	-1079.98	Grass
-1183.89	2265.98	-55.08	762.91	-62.76	162.98	-1286.25	-2160.94	-705.77	-903.56	162.98	-675.55	-1637.96	-1140.18	-683.84	Standard
-1299.84	2150.02	-171.03	646.96	-178.71	47.02	-1402.21	-2276.90	-821.73	-1019.52	47.02	-791.51	-1753.92	-1256.14	-799.80	Nat.Protein
-1468.36	1981.50	-339.55	478.44	-347.23	-121.49	-1570.73	-2445.41	-990.25	-1188.04	-121.49	-960.03	-1922.43	-1424.66	-968.31	Avoparcin
-1320.79	2129.07	-191.98	626.01	-199.66	26.08	-1423.16	-2297.84	-842.68	-1040.47	26.08	-812.46	-1774.86	-1277.09	-820.74	Bentonite
-1390.26	2059.60	-261.45	556.54	-269.13	-43.39	-1492.63	-2367.31	-912.15	-1109.94	-43.39	-881.93	-1844.33	-1346.56	-890.21	*Grass*
-1964.73	1485.14	-835.92	-17.93	-843.59	-617.86	-2067.09	-2941.78	-1486.61	-1684.40	-617.86	-1456.39	-2418.80	-1921.02	-1464.68	*Standard*
-1555.59	1894.28	-426.78	391.21	-434.46	-208.72	-1657.95	-2532.64	-1077.47	-1275.26	-208.72	-1047.25	-2009.66	-1511.88	-1055.54	*Nat.Protein*
-1642.06	1807.80	-513.25	304.74	-520.93	-295.19	-1744.43	-2619.11	-1163.94	-1361.73	-295.19	-1133.72	-2096.13	-1598.36	-1142.01	*Avoparcin*
-1398.19	2051.67	-269.38	548.61	-277.06	-51.32	-1500.56	-2375.24	-920.07	-1117.86	-51.32	-889.85	-1852.26	-1354.49	-898.14	*Bentonite*
-926.29	2523.57	202.52	1020.51	194.84	420.58	-1028.66	-1903.34	-448.18	-645.96	420.58	-417.95	-1380.36	-882.59	-426.24	Grass
-786.68	2663.18	342.13	1160.12	334.45	560.19	-889.05	-1763.73	-308.56	-506.35	560.19	-278.34	-1240.75	-742.98	-286.63	Standard
-228.78	3221.08	900.03	1718.02	892.35	1118.08	-331.15	-1205.84	249.33	51.54	1118.08	279.55	-682.86	-185.08	271.26	Nat.Protein
1316.38	4766.25	2445.19	3263.18	2437.52	2663.25	1214.02	339.33	1794.50	1596.71	2663.25	1824.72	862.31	1360.09	1816.43	Avoparcin
73.63	3523.49	1202.44	2020.43	1194.76	1420.50	-28.74	-903.42	551.75	353.96	1420.50	581.97	-380.44	117.33	573.68	Bentonite
	3449.86	1128.81	1946.80	1121.13	1346.87	-102.37	-977.05	478.11	280.32	1346.87	508.33	-454.07	43.70	500.05	*Grass*
-3449.86		-2321.05	-1503.06	-2328.73	-2103.00	-3552.23	-4426.92	-2971.75	-3169.54	-2103.00	-2941.53	-3903.93	-3406.16	-2949.81	*Standard*
-1128.81	2321.05		817.99	-7.68	218.06	-1231.18	-2105.86	-650.70	-848.49	218.06	-620.48	-1582.88	-1085.11	-628.76	*Nat.Protein*
-1946.80	1503.06	-817.99		-825.67	-599.93	-2049.17	-2923.85	-1468.69	-1666.48	-599.93	-1438.47	-2400.87	-1903.10	-1446.75	*Avoparcin*
-1121.13	2328.73	7.68	825.67		225.73	-1223.50	-2098.19	-643.02	-840.81	225.73	-612.80	-1575.20	-1077.43	-621.08	*Bentonite*
-1346.87	2103.00	-218.06	599.93	-225.73		-1449.23	-2323.92	-868.75	-1066.54	0.00	-838.53	-1800.94	-1303.16	-846.82	Grass
102.37	3552.23	1231.18	2049.17	1223.50	1449.23		-874.69	580.48	382.69	1449.23	610.70	-351.70	146.07	602.42	Standard
977.05	4426.92	2105.86	2923.85	2098.19	2323.92	874.69		1455.17	1257.38	2323.92	1485.39	522.98	1020.76	1477.10	Nat.Protein
-478.11	2971.75	650.70	1468.69	643.02	868.75	-580.48	-1455.17		-197.79	868.75	30.22	-932.19	-434.41	21.93	Avoparcin
-280.32	3169.54	848.49	1666.48	840.81	1066.54	-382.69	-1257.38	197.79		1066.54	228.01	-734.40	-236.62	219.72	Bentonite
-1346.87	2103.00	-218.06	599.93	-225.73	0.00	-1449.23	-2323.92	-868.75	-1066.54		-838.53	-1800.94	-1303.16	-846.82	*Grass*
-508.33	2941.53	620.48	1438.47	612.80	838.53	-610.70	-1485.39	-30.22	-228.01	838.53		-962.41	-464.63	-8.29	*Standard*
454.07	3903.93	1582.88	2400.87	1575.20	1800.94	351.70	-522.98	932.19	734.40	1800.94	962.41		497.77	954.12	*Nat.Protein*
-43.70	3406.16	1085.11	1903.10	1077.43	1303.16	-146.07	-1020.76	434.41	236.62	1303.16	464.63	-497.77		456.35	*Avoparcin*
-500.05	2949.81	628.76	1446.75	621.08	846.82	-602.42	-1477.10	-21.93	-219.72	846.82	8.29	-954.12	-456.35		*Bentonite*

Appendix 11 - Detailed sensitivity analyses of profit changes when the beef purchase price, fertiliser costs and supplement costs are increased or decreased by 10% (R)

			Beef purchase price		Fertilizer cost		Supplement cost	
			+ 10%	- 10%	+ 10%	- 10%	+ 10%	- 10%
Veld	Grass	-	-	-	-	-	-	-
Season 1	Standard	-8.49	-68.01	51.04	-8.49	-8.49	-31.21	14.23
	Nat.Protein	-273.58	-273.94	-273.22	-273.58	-273.58	-285.10	-262.06
	Avoparcin	-99.08	-126.59	-71.57	-99.08	-99.08	-114.79	-85.02
	Bentonite	-112.58	-123.60	-101.57	-112.58	-112.58	-124.93	-101.61
	Grass	*-224.41*	-229.74	-219.07	-224.41	-224.41	-224.41	-224.41
	Standard	*41.06*	-32.91	115.02	41.06	41.06	18.33	63.78
	Nat.Protein	*-116.54*	-120.17	-112.92	-116.54	-116.54	-128.07	-105.02
	Avoparcin	*-207.25*	-230.67	-183.82	-207.25	-207.25	-222.95	-193.19
	Bentonite	*-107.12*	-111.46	-102.78	-107.12	-107.12	-119.46	-96.15
	Profitable	1	0	2	1	1	1	2
Season 2	Grass	-	-	-	-	-	-	-
	Standard	-396.14	-440.72	-351.57	-396.14	-396.14	-414.00	-378.29
	Nat.Protein	-280.19	-273.02	-287.36	-280.19	-280.19	-289.24	-271.13
	Avoparcin	-111.02	-108.24	-113.80	-111.02	-111.02	-123.36	-99.98
	Bentonite	-259.24	-247.04	-271.45	-259.24	-259.24	-268.94	-250.62
	Grass	*-189.77*	-173.88	-205.66	-189.77	-189.77	-189.77	-189.77
	Standard	*384.69*	372.13	397.26	384.69	384.69	366.84	402.55
	Nat.Protein	*-24.45*	-6.89	-42.01	-24.45	-24.45	-33.50	-15.39
	Avoparcin	*62.68*	47.31	78.05	62.68	62.68	50.33	73.72
	Bentonite	*-181.84*	-182.89	-180.80	-181.84	-181.84	-191.54	-173.22
	Profitable	2	2	2	2	2	2	2
Kikuyu HSR	Grass	732.91	84.92	1380.89	586.90	878.91	732.91	732.91
Season 1	Standard	-1074.17	-1793.20	-355.13	-1220.18	-928.17	-1227.36	-920.98
	Nat.Protein	-620.93	-1339.97	98.10	-766.94	-474.93	-774.12	-467.74
	Avoparcin	1727.41	1061.00	2393.81	1581.40	1873.41	1565.71	1872.08
	Bentonite	2.98	-839.74	845.70	-143.03	148.98	-150.21	139.15
	Grass	235.96	295.87	176.05	89.95	381.96	235.96	235.96
	Standard	-604.67	-544.76	-664.58	-750.68	-458.67	-757.86	-451.48
	Nat.Protein	1142.73	405.27	1880.18	996.72	1288.73	989.54	1295.92
	Avoparcin	135.98	-638.31	910.28	-10.03	281.98	-25.72	280.66
	Bentonite	224.12	-471.24	919.47	78.11	370.12	70.93	360.28
	Profitable	7	4	8	5	7	5	7
Season 2	Grass	-653.74	-1457.83	150.34	-799.75	-507.74	-653.74	-653.74
	Standard	-793.35	-1584.28	-2.43	-939.36	-647.35	-913.72	-672.99
	Nat.Protein	-1351.25	-2184.28	-518.22	-1497.26	-1205.25	-1471.61	-1230.88
	Avoparcin	-2889.73	-3743.81	-2035.65	-3035.74	-2743.73	-3016.78	-2776.05
	Bentonite	-1653.66	-2523.54	-783.79	-1799.67	-1507.66	-1774.03	-1546.67
	Grass	*-1580.03*	-2428.85	-731.21	-1726.04	-1434.03	-1580.03	-1580.03
	Standard	*1869.83*	1110.48	2629.18	1723.82	2015.83	1749.47	1990.19
	Nat.Protein	*-451.22*	-1165.83	263.39	-597.23	-305.22	-571.58	-330.86
	Avoparcin	*373.46*	-406.94	1153.85	227.45	519.46	246.41	487.13
	Bentonite	*-458.90*	-1370.88	453.08	-604.91	-312.90	-579.26	-351.91
	Profitable	2	1	5	2	2	2	2
Kikuyu LSR	Grass	-804.84	-1018.12	-591.57	-950.85	-658.84	-804.84	-233.17
Season 1	Standard	-1250.10	-1498.46	-1001.74	-1396.11	-1104.10	-1298.73	-1720.61
	Nat.Protein	-1198.57	-1419.36	-977.78	-1344.58	-1052.57	-1247.20	-2595.30
	Avoparcin	-1127.63	-1350.92	-904.33	-1273.64	-981.63	-1178.96	-1140.13
	Bentonite	-1953.32	-2199.17	-1707.46	-2099.33	-1807.32	-2001.95	-1337.92
	Grass	*-798.88*	-1049.74	-548.01	-944.89	-652.88	-798.88	-233.17
	Standard	*-3414.68*	-3690.61	-3138.76	-3560.69	-3268.68	-3463.32	-1109.91
	Nat.Protein	*-1592.33*	-1825.65	-1359.01	-1738.34	-1446.33	-1640.96	-2072.31
	Avoparcin	*-1774.57*	-2030.45	-1518.69	-1920.58	-1628.57	-1825.90	-1574.54
	Bentonite	*-927.98*	-1176.34	-679.62	-1073.99	-781.98	-976.61	-1118.19
	Profitable	0	0	0	0	0	0	0
Season 2	Grass	-	-	-	-	-	-	-
	Standard	-1682.40	-1880.72	-1484.08	-1828.41	-1536.40	-1201.47	-1644.19
	Nat.Protein	-2557.09	-2727.84	-2386.34	-2703.10	-2411.09	-1149.94	-2518.88
	Avoparcin	-1099.79	-1278.06	-921.53	-1245.80	-953.79	-1081.70	-1063.71
	Bentonite	-1299.71	-1485.49	-1113.92	-1445.72	-1153.71	-1910.09	-1265.74
	Grass	-	-	-	-	-	-	-
	Standard	*-1071.70*	-1254.98	-888.42	-1217.71	-925.70	-3366.05	-1033.49
	Nat.Protein	*-2034.10*	-2237.43	-1830.77	-2180.11	-1888.10	-1543.70	-1995.89
	Avoparcin	*-1534.21*	-1765.11	-1303.31	-1680.22	-1388.21	-1728.64	-1498.12
	Bentonite	*-1079.98*	-1250.73	-909.23	-1225.99	-933.98	-884.75	-1046.02
	Profitable	0	0	0	0	0	0	0