Seasonal variation of pasture quality on commercial equine farms in New Zealand

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Robyn Lesley Hirst

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Abstract

The equine production system in New Zealand is largely pasture-based and as a result broodmares, foals and young horses acquire a significant percentage of their nutrition primarily from pasture. The reliance on pasture as the main nutrient source in New Zealand is in distinct contrast to the more intensive equine production systems found in other countries such as in Europe and North America. However, there is increasing scientific evidence that raising horses primarily on pasture may provide the optimal environment for the development of a sound and durable athlete.

In addition, the supply of a balanced nutritional ration for the broodmare is important as inadequate nutrition can lead to reduced fertility. The requirement to produce a live healthy foal every year is crucial to maintaining the production cycle as mares which fail to conceive within a 25-day window post-partum eventually have to forgo a mating season which is costly to the business which relies on the sale of a young horse each year.

The compositional data gathered during this study showed that equine breeding farm pastures were rarely deficient in energy, protein or fibre. The low energy content of pasture in summer and in some cases autumn was caused by high dead matter content and reproductive stem content. The presence of reproductive stem content and dead matter in the sward is linked to poor pasture utilisation, but can also be present during prolonged periods of climatic pressure (lack of rainfall). Lower nutritional quality of pasture is likely to be the main limitation to animal performance, especially in regions where summer temperature is high, rainfall is low, forage availability is reduced and the stocking density is high. During the breeding season commercial equine breeding farms experience a period of high stocking density which can be detrimental pasture quality and availability.

Consideration of the recommended nutritional requirements of horses were made on the basis that there was sufficient dry matter (DM) available for the bloodstock to consume. The pasture management study found that there is an opportunity within the equine production system for improved pasture utilisation and production to allow for the provision of adequate nutrition to valuable bloodstock.

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Abbreviations

ADF	Acid detergent fibre
ADG	Average daily gain
Ash	Mineral
BW	Bodyweight
CP	Crude protein
DCAD	Dietary cation-anion difference
DE	Digestible energy
DM	Dry matter
DMI	Dry matter intake
DOD	Developmental orthopaedic disease
DW	Dry weight
FV	Feeding value
FW	Fresh weight
GE	Gross energy
GR	Growth rate
ME	Metabolisable energy
Mo	Month (s)
NDF	Neutral detergent fibre
NIRS	Near infra-red reflectance spectroscopy
NRC	National Research Council
NV	Nutritive value
NZ	New Zealand
OMD	Organic matter digestibility
RSU	Revised stock unit
SB	Standardbred
SD	Standard deviation
SEM	Standard error of the mean
Sol CHO	Soluble carbohydrate
SSS	Soluble starch and sugars
SU	Stock unit
TB	Thoroughbred
VFI	Voluntary feed intake

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Chapter 1
Introduction, objectives and thesis outline

1.0 Introduction

The temperate climate of New Zealand allows grazing livestock to obtain a significant portion of their nutrition from pasture year-round. Seasonality and year to year variation of pasture production must be understood so that the utilisation of pasture and the resulting livestock performance can be optimised. As in the sheep, beef and dairy farming systems in New Zealand, the equine production system in New Zealand is largely pasture-based, with a significant percentage of the horse's nutrition acquired primarily from pasture.

The reliance on pasture as the main nutrient source is in distinct contrast to the more intensive equine production systems found in Northern Hemisphere countries. In NZ, the horse is primarily pasture reared (Morel *et al.* 2007, Rogers *et al.* 2007, Brown-Douglas *et al.* 2005, Grace 2005, Hoskin & Gee 2004, Grace *et al.* 2003), and there is increasing scientific evidence that this may provide the optimal environment for the development of a sound and durable athlete (Rogers *et al.* 2007).

The equine production system in New Zealand differs from other more familiar pastoral production systems (sheep, beef and dairy), where the aim is maximal growth rate and milk production. By contrast, optimised growth is required of the equine subject, rather than maximal. While maximal growth is aimed at achieving the maximum production from any given situation, optimised growth requires that the animal is provided with sufficient nutrients for any given physiological stage. This optimised nutritional requirement of the horse potentially means that traditional farming practices employed for maximal milk and meat production may not be entirely applicable for raising horses. This has implications for the pasture species cultivated and the pasture management practices relating to horses, which could in turn provide an environment for growth that ultimately maximises the horse's athletic potential.

The nutritional status of the broodmare is a factor in the reproductive performance of the mare. Poor and inadequate nutrition can lead to reduced reproductive efficiency in the mare. From a business perspective, the requirements of producing a live healthy foal every year is crucial as mares which fail to conceive within a 25-day window post-partum eventually have to forgo a mating season which is costly to the business which relies on the sale of a young horse each year (Bosh *et al.* 2009). Thus, the supply of a balanced ration which ensures adequate nutrition for each situation is important to maintaining the production cycle.

NZ perennial ryegrass-based pastures are regarded to be the best in the world for growing horses (Rogers *et al.* 2007). Published data about the variation in the seasonal fluctuation and quality of pasture on equine breeding farms is scarce. There is poor understanding of the differences between breeding farms and regions within New Zealand. Grace (2005) conducted research at Flock House in the Rangitikei as part of a broader research programme where pasture fed to the horses was analysed. These data are available, but it is for one property, for one region of NZ. Goold *et al.* (1988) also investigated the nutritional composition of pasture on a small number of Waikato studs, again for a very limited cross-section of the overall industry.

The quantification of the quality and composition of the pasture offered to valuable bloodstock, in addition to the investigation of pasture management strategies, will provide an insight into the provision of optimal use of both pastures and supplements when formulating balanced diets for horses.

1.1 Objectives

The hypothesis of this study is that pastures offered to New Zealand bloodstock on commercial equine farms is of sufficient nutritional quality with respect to the published NRC requirements (Anonymous 2007), for horses. In addition the pasture management on equine properties remains largely unchanged (as opposed to the advanced pasture management within the dairy system), and is often secondary to the large amount of supplementary feeding that occurs on equine stud farms.

Consequently, the objectives of this study are to:

- Provide baseline data on the seasonal variation in pasture quality by analysing the chemical and botanical composition of pasture on a selection of commercial equine breeding farms in New Zealand (*Chapter 3*).
- Review the pasture management practices on equine farms in New Zealand (*Chapter 4*).
- Compare data from the pasture study to the published nutritional requirements of growing horses to determine if pastures offered to growing bloodstock in New Zealand are sufficient to meet the desired outcome resulting in healthy growth and performance. (*Chapter 3*)
- Interpret pasture management strategies in combination with pasture quality data (*Chapter 5*).

1.2 Thesis outline

The thesis is presented in five chapters. Chapter two presents a summary of the relevant literature of the equine subject including its nutritional requirements and the equine production system in New Zealand. Pasture production and management and quality assessment are reviewed in chapter two as a foundation to the experimental chapters. Pasture data (chemical and botanical composition), collected over one calendar year are presented in chapter three. Pasture management strategies utilised on equine breeding farms are compared and discussed in chapter four. Finally, chapter five is a general discussion integrating the pasture quality data from chapter three with pasture management strategies from chapter four. Consideration of the nutritional requirements of horses published by the National Research Council (NRC), (Anonymous 2007), (in relation to the pasture compositional data gathered during the study), is presented in chapter two.

Chapter 2

Literature Review

2.0 Introduction

The New Zealand (NZ) equine production system is largely pasture-based, with a significant percentage of the horse's nutrition acquired primarily from pasture. The reliance on pasture as the main nutrient source is in distinct contrast to the more intensive equine production systems found in other countries such as Europe and North America. In NZ, the horse is primarily pasture reared (Rogers *et al.* 2007,Brown-Douglas *et al.* 2005, Grace 2005, Hoskin & Gee 2004, Grace *et al.* 2003), and there is increasing scientific evidence that this may provide the optimal environment for the development of a sound and durable athlete (Rogers *et al.* 2007).

While it is accepted that young horses in sales preparation and horses in training receive a significant portion of their nutrients through cereal-based supplement feed supplements, generally broodmares and young growing stock rely on pasture for a large amount of their nutrition, with a small amount coming from a supplementary feed source. The degree of this supplementary feeding is related to a number of factors, including the stocking rate of the particular farm and the supply, availability, and dry matter (DM), production of pasture. It is important that breeders utilise a management system that provides a nutritional environment for the growth of a healthy sound horse which allows it to maximise its athletic potential (Rogers *et al.* 2007).

Along with the nutritional benefits of horses kept at pasture it is also beneficial for them to be grown in a more natural environment, i.e., at pasture, which allows the ability to graze continuously. Horses kept at pasture have greater freedom for natural behaviour and more opportunity for social interaction, and the prevalence of stereotypic behaviours is reduced in pastured horses compared with horses that are stabled (Pell & McGreevy 1999). Ongoing research indicates that early exercise (as pasture reared horses would experience), may potentially be beneficial for long-term soundness (Rogers *et al.* 2009).

Horses kept at pasture are able to graze continuously and may have a reduced risk of developing digestive problems associated with high-grain restricted diets, including colic and gastric ulcers (Hudson *et al.* 2001). However, more recent studies of broodmares grazing at pasture showed a high prevalence of gastric ulceration (70.9%), which is contradictory to current thought that pastured horses are a low-risk group for gastric ulcers (le Jeune *et al.* 2009). However, the study reporting the high prevalence was restricted to one farm, in one locality, therefore a more comprehensive study would be necessary to confirm this as a global occurrence. A diet containing sufficient levels of fibrous forage is still regarded to reduce the risk of gastric ulceration and digestive upsets.

The grazing of horses at pasture can be associated with a number of animal health problems including exposure to parasites or increased risk of internal parasites (Hoskin & Gee 2004, Cuddeford 2006), and diseases related to the presence of pasture-associated toxins, e.g., ryegrass staggers due to the presence of the toxin producing fungal endophyte *Neotyphodium lolli,* which is present in most perennial ryegrass pastures.

The lack of published information about the feed intake of the horse and the seasonal nature of the nutritive value of horse pasture means that in some instances the horse's diet may be lacking in one or more essential nutrients (Hoskin & Gee 2004).

The quantification of the quality and composition of the pasture offered to valuable bloodstock, in addition to the investigation of pasture management strategies, will provide an insight into the provision of optimal use of both pastures and supplements when formulating balanced diets for horses. It may also reveal opportunities to establish a higher degree of pasture management as is found on more traditional livestock farming systems in NZ.

The aim of this literature review is to examine peer-reviewed literature about the seasonal supply of nutrients to the predominantly pasture-fed horse. In some of the subject areas there is a lack of peer-reviewed data from literature - these non-peer reviewed studies have been cited where they provide relevant data.

The topics covered in this literature review are as follows: the digestive physiology of the horse, the nutrient requirements of the horse, the NZ equine production system, equine pasture in NZ (production, quality and management), and methods used to assess pasture quality (botanical and chemical composition).

2.1 Digestive physiology of the horse

The horse has evolved as a large non-ruminant grazing herbivore. In the wild the horse browses almost continuously to meet its nutritional requirements (grazing up 14 -18 hours/day), potentially covering up to 17km/day whilst grazing (Duncan 1980). Domesticated horses kept in temperate to sub-tropical zones of the world rely on pastures to supply the majority of their nutritional requirements (Hoskin & Gee, 2004).

With the process of domestication inevitable stresses have been placed on the horse's digestive system. Physiologically, the horse's gut is designed to take in small amounts at regular intervals with a capacity to process a wide variety of grasses herbs and shrubs (Pilliner & Davies 2004), which is generally at odds with how domesticated horses are managed. Domestication has resulted in the control of feeding patterns, both in types of forage offered and the feeding regime itself.

The grazing and browsing existence of horses in the wild results in the selection of forages containing relatively large amounts of water, soluble proteins, lipids, sugars and structural carbohydrates, with little starch (Frape 1998, 2010). Modern-day feeding of cereal-based concentrates generally consists of one or two large feeds per day comprising a diet of unfamiliar materials, particularly starchy cereals, protein concentrates and dried forages (Frape 1998, 2010).

Forages are a primary component of horse diets as they are necessary for the normal functioning of the equine digestive system (Hall & Comerford 1992). Forage requirements are most easily supplied by pasture and conserved pasture as hay or baleage. Generally, for optimal horse growth and development, forages should constitute at least 50% or more of the total weight of feed consumed daily (Hall & Comerford 1992). The forage can be fresh, dried, or ensiled, and this may influence the voluntary feed intake (VFI), and the choice of forage intake.

Mature horses generally consume 2-2.5% of their bodyweight in feed each day, i.e., a 454 kg horse can consume 9.1 to 11.4 kg (90% DM), of feed daily (Hall & Comerford 1992). The recommended air-dried feed consumption rates (assuming 90% DM), are shown in Table 2.1

Table 2.1: Recommended air-dried feed consumption rates (90% DM).Modified from Hall & Comerford (1992), NRC requirements for horses (2007).

	Forage[a]	Concentrate[b]	Total
	kg per 100 kg body weight		
MATURE HORSE			
Maintenance	0.7-0.9	0.0-0.2	0.7-0.9
Mare, late gestation	0.5-0.9	0.5-0.7	0.7-0.9
Mare, early lactation	0.5-0.9	0.5-0.9	0.9-1.4
Working horse[c]	0.5-0.9	0.3-0.7	0.8-1.1
YOUNG HORSE			
Weanling foal (6 mo)	0.2-0.5	0.7-1.4	0.9-1.6
Yearling (12mo)	0.5-0.7	0.5-0.9	0.9-1.4
Two-year old (24mo)	0.5-0.7	0.5-0.7	0.8-1.1

Notes: [a]Plant materials that are high in fibre (hay or pasture).[b] Feeds that are high in energy and low in fibre (grain is primary component). [c]Moderate work. Values depend on forage and concentrate quality.

In a feeding experiment conducted by Muller & Uden (2007), horses were given a forage choice. The four forages offered were silage, 2 haylages (each with a different DM), and hay, which were all made from the same grass crop. Silage was eaten in largest amounts and for the longest time periods by comparison to the other forages. Silage was never left in favour of the other forages and the hay was never completely consumed. Of the forages offered, silage has the highest metabolisable energy (ME) content and the lowest DM content.

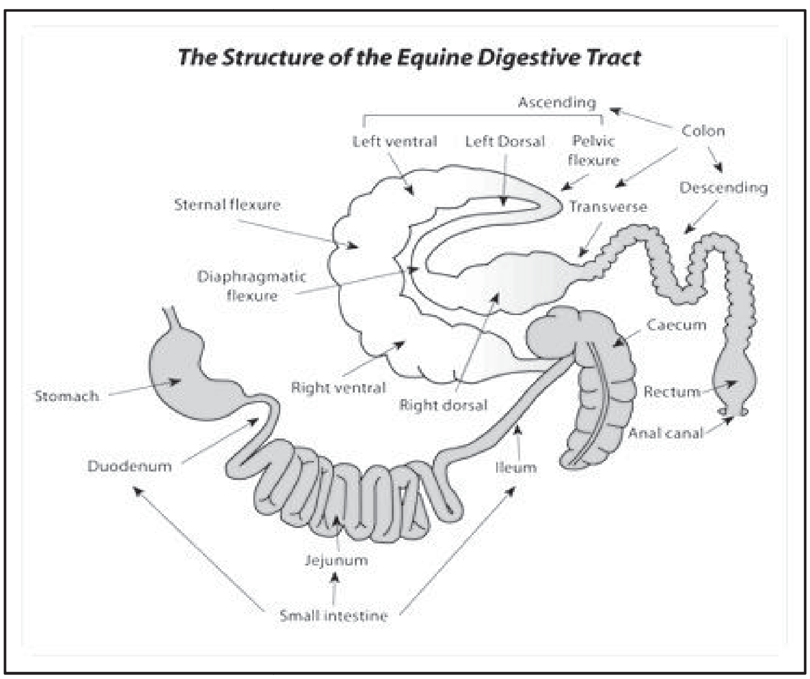
In addition to their browsing activity, horses by contrast to ruminants, are quite different in the way that they select, ingest and subsequently process their food. The horse's upper lip is extremely mobile, sensitive and strong and is able to select palatable forages which it then bites off small pieces of food in a very selective manner (Frape 2010), whereas in the cow the tongue is used to place the forage between the teeth. Unlike the ruminant, the horse has both upper and lower incisors which enable it to graze closely by shearing off forage.

More intensive mastication by the horse means that the ingestion rate of long hay, per kg of metabolic body weight (BW), is three to four times as fast in cattle and sheep than it is in ponies and horses for long hays (Frape 2010). Although, the number of chews per minute is similar according to published observations (73-92 for horses and 73-115 for sheep), for long hay (Frape 2010). The DM intake per kg of metabolic BW for each chew is 2.5 mg in horses (possibly lower, Frape 2010) and 5.6-6.9 mg in sheep. Therefore, the horse needs longer periods of grazing each day than the ruminant does.

Being selective grazers, horses often reject food once in the mouth - possibly following sensory rejection due to lack of acceptability (Cuddeford 2005). The premolars and molars crush and grind the forage which is accompanied by large amounts of saliva, (at least 15L may be produced in a 24-hour period by a 500kg horse (Cuddeford 2005). The functionality of the horse's teeth is vital to health and well-being of the horse. Diseased teeth can cause digestive disturbance, colic, and compromise general health (Frape 1998). After food is swallowed it passes to the relatively small stomach, which makes up approximately 10% of the horse's total digestive system (Frape 1998).

The unique digestive system of the horse can be considered in two parts, the foregut and hindgut (Figure 2.1). The horse's foregut is similar to simple stomached animals such as the human and pig (mouth, pharynx, oesophagus, stomach and small intestine). The role of its hindgut (caecum, large and small colon), has some similarity to that of the rumen in sheep and cattle, largely as a fermentation chamber for the digestion and absorption of structural carbohydrates. Passage though the stomach and small intestine is rapid (5 hours on average), whereas digesta passing through the caecum and colon is much slower (35 hours on average), (Van Weyenberg et al 2006).

The horse is less efficient at the digestion and absorption of nutrients compared to the ruminant largely because in the ruminant the breakdown of fibrous matter occurs in the rumen which is located before the small intestine, the main site of nutrient absorption. The nutrients obtained from fermentation in the hindgut of the horse are produced after the small intestine, resulting in a less efficient capture of available nutrients from the equine diet.



From: www.utafoundation.org/P&L/ch3-4_1.jpg digestive tract downloaded 16 September 2009

Figure 2.1: **The structure of the equine digestive tract.**

In the horse the small intestine is the major site of nutrient absorption (Frape 1998). A high proportion of the available starch ingested is degraded to glucose before absorption in the small intestine (Harris 2001). A proportion of the dietary fibre is processed in the hindgut to VFAs. Dietary protein is mainly digested in the foregut of the horse through enzymatic digestion in the stomach and the small intestine (Anonymous 2007). Dietary minerals are absorbed in the small intestine.). Table 2.2 provides a summary of the digestion in the horse (Pilliner & Davies 2004).

Table 2.2: Summary of Digestion in the Horse, (Pilliner & Davies 2004).

	Secretion	Digestion Products	Absorbed	Material passed on
Stomach	HCl Intrinsic factor Mucus	Lactic Acid	Minimal	All ingesta and gastric secretions
Small Intestine	Sodium bicarbonate Pancreatic Enzymes Bile Mucus	Amino acids Glucose and Other simple sugars Triglycerides Fatty acids	Amino acids Simple sugars Fatty acids Vitamins Minerals Ca, K, Cl, Zn, Cu	Fibre Water
Caecum	Water	VFAs B vitamins Microbial protein	VFAs Vitamins* Amino acids*	Fibre
Large Colon		VFAs B vitamins	VFAs Thiamine Amino acids water P	Indigestible Components Waste material

*It is unclear how much of these end products are actually absorbed.

The horse differs from the ruminant in that the composition of its body fat is influenced by the composition of dietary fat (Frape 2010). The small intestine is the primary site for the absorption of dietary fat and long-chain fatty acids. This process is facilitated by bile which continuously drains from the liver (Frape 2010).

The caecum and large intestine is where the fibrous components undergo fermentation to release the available nutrients (Janis 1976). Caecal digestion in the horse is an adaptation to obtain energy from high fibre content herbage, provided that the intake is not limited by the actual quantity of herbage available (Janis 1976, Hoskin & Gee 2004). The final step in digestion occurs in the hindgut containing large numbers of bacteria, fungi and protozoa that are responsible for the breakdown of fibrous carbohydrates (Hoskin & Gee 2004). The type of micro-organisms present are related to the horse’s diet, e.g. high starch diets will have a different profile of micro-organisms required for digestion than a diet consisting of hay. The feed source also affects the ratio of volatile fatty acids (VFAs), the product of microbial fermentation (Frape 1998). Potentially a very small amount of the hindgut microbial protein is absorbed, although how much is not known, therefore it is very likely it would contribute very little to the horse's overall amino acid requirements (Frape 1998, Pilliner & Davies 2004). Conversely in the ruminant microbial protein is utilised by the animal by absorption in the small intestine (Waghorn *et al.* 2007).

In the horse most of the digestion of nutrients occurs in the small intestine, followed by the fermentation and digestion of fibrous components in the hindgut (Frape 2010). In the ruminant generally, 55-65% of apparent digestion occurs in the rumen, and about 20-30% in the small intestine and 5-15% in the large intestine (Waghorn *et al*. 2007).

2.2 Nutrient requirements of horses

The horse needs to eat food to provide fuel for its body in the form of energy, which in turn provides material for the building and maintenance of body tissues and the supply the nutrients required to regulate the wide range of body processes. The nutrients obtained from the digestive system assist the horse to grow, live and reproduce and perform as an athlete. A diet which is correctly balanced for energy, protein, minerals and fibre will allow for optimal growth/development while reducing the risk of nutrition-related diseases.

For horses to develop optimally and perform at a high level of physical fitness, knowledge of the nutrients available in a diet, the feed intake level combined with a sound knowledge of the horse's digestive system will allow for diets to be tailored with the most optimal production response in mind. Given horses are raised on pasture in New Zealand, knowledge of the nutritional composition of pasture specifically for horses is essential to determine if these requirements are being met (Hoskin & Gee 2004).

Energy is required for all the living processes of the horse. Sugars and starch are the main pasture components which provide energy for horses (Hunt 1994). Overall, the horse obtains its dietary energy from four main dietary energy sources: hydrolysable carbohydrates, e.g., starch; the non-starch polysaccharides or fibre components of the diet cellulose, e.g., pectins, hemicelluloses; protein (although considered an inefficient nutritional source of energy), and finally fats (which normally constitute less than 3% of total feed intake), (Harris 2001).

There are several ways of describing the energy potential of a horse diet, however they are usually described in terms of the amount of digestible energy present, Digestible Energy (DE) MJ/kg dry matter (DM), (Lawrence 2001), (Figure 2.2). DE is the gross energy (GE), of the feed minus faecal losses. Two factors which impact the amount of DE in a feed are the gross energy (GE) content of the feed and the digestibility of the energy-containing components (Anonymous 2007).

Much of the data available from feed analysis is based on the analysis of ruminant diets and most feeds are reported in terms of the metabolisable energy (ME) MJ/Kg DM content, which accounts for losses in the faeces, urine and methane gas. Figure 2.2 illustrates the terminology frequently used with respect to dietary energy. The efficiency by which ME is used depends on the type of metabolite. In horses the efficiency of conversion of DE to ME was found to be 90% for a mixed diet and 87% for a hay diet, (Vermorel *et al.* 1991), while the efficiency of converting ME to NE is estimated by Vermorel et al (1997) to be 85% for glucose, 80% for long chain fatty acids, 70% for amino acids and 63-68% for VFAs (Frape 2010).

There is an online calculator which can be used to convert DE to ME (Animal Science – University of Davis, California). It uses a conversion factor just over 80% to account for losses in the faeces, urine and methane gas. These types of assumptions are made on a theoretical basis and should be considered as guidelines to diet and ration formulation. It can be found at: http://animalscience.ucdavis.edu/java/LivestockSystemMgt/Conversion/energy.htm.

Granted there are few studies which examine the losses associated when converting DE to ME in horses, but as for any theoretical calculation an allowance for the potential error should always be considered. More detailed studies which help to more accurately predict conversions factors would be useful for reducing confusion when DE and ME are used, often interchangeably by feed suppliers and producers, particularly in the equine area.

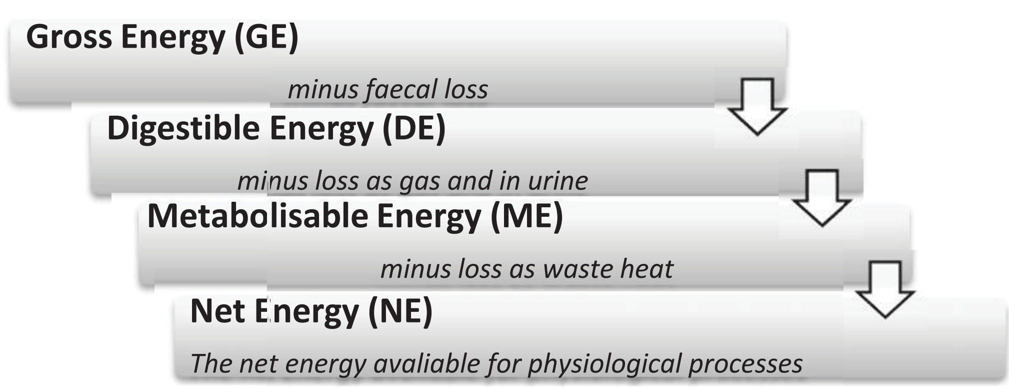


Figure 2.2: Dietary Energy

Protein is a major component of most tissues in the body, second only to water (Anonymous 2007). Digestion breaks down dietary proteins into amino acids which can be absorbed and then used to reform the proteins the horse requires. The breakdown and absorption of protein largely occurs in the small intestine (ileum) via the horses own digestive enzymes (Frape 1998).

The young horse needs a significant amount of protein for growth (Hunt 1994). The actual individual amino acid requirements for the horse have not been established, with the exception of lysine. As a non-ruminant species there are 10 presumed essential amino acids which cannot be synthesized by the body and must be obtained from dietary sources (Anonymous 2007). The dietary protein requirement is a function of the amino acid needs of the animal, which changes with different physiological stages; the amino acid composition of the dietary protein; and the digestibility of the protein and the microbial protein resulting from the microbial fermentation in the hindgut (Ott 2001). Protein is often reported as crude protein, (CP) g/kg DM. Crude protein, (CP) relates to the amount of protein ingested in the feed, not the amount actually digested, (DP) g/kg. The challenge in feeding horses is to provide sufficient quantities of protein which allows for a supply for the body to draw on for synthesising tissue, enzymes and hormones, in addition to repairing tissue (Anonymous 2007).

Much of the research concerning the mineral requirements of a horse’s diet has been based largely on digestibility experiments using a small number of horses fed conserved forage and grain-based diets (Pagan 2001) and no information has been published on the relative bioavailability of minerals contained in fresh forages with respect to horses (Hoskin & Gee 2004). Mineral requirements are often extrapolated from ruminant digestibility trials and given the comparatively different digestive physiology between ruminants and horses this has potential for error.

There are fourteen essential minerals that perform important functions in the body (Hunt 1994). Horses need minerals for vital cellular processes as well as for the skeleton and teeth. Table 2.3 outlines the mineral requirements of the horse and some of the important functions they perform (Hunt 1994, Anonymous 2007).

Pasture mineral composition varies widely, influenced by botanical composition, season, fertiliser history and soil type (Hunt 1994). Most well managed pastures should provide adequate macro-mineral intakes for horses, but not necessarily micro-minerals (Hunt 1994). Clovers usually have a higher micro-mineral content than grasses, except for selenium which is higher in grasses. There are also many instances where the absorption of a particular mineral is affected and/or prevented by the presence of an antagonist.

Some types of pasture can be limiting for calcium, e.g., horses grazing primarily Kikuyu grass will possibly require some form of calcium supplementation. This is primarily due to the action of oxalates, present in Kikuyu grass.

Table 2.3: Minerals required by horses, (Hunt 1994, Anonymous 2007).

Macro Element	Important Function	Micro Element	Important Function
Ca, P	Mineral matrix of skeleton	Fe, Cu, Mn, Zn	Developing and forming fibrous connective tissues and cartilage, strengthening bones and teeth.
Na, K	Nerve function & tissue water balance	Zn, Mn, Cu, Se	Assist in function of enzymes involved in the processing of CHO, fat, protein, and nucleic acids
Mg	Assist in function of enzymes involved in the processing of CHO, fat, protein, and nucleic acids. Participates in muscle contractions.	I	Essential for production of thyroid hormones which regulate basal metabolism.
Cl	Extracellular anion involved in acid-base balance and osmotic regulation. Essential component of bile, (gastric secretions necessary for digestion).	Co	Intestinal bacteria use dietary Co in synthesis of vitamin B_{12}. Inter-related with Fe and Cu for blood cell formation.
S	Major role in the structural components of almost all proteins and enzymes in the body.		

Lush pasture may not meet all of the horse's mineral requirements. Healthy plant growth can occur without some minerals that are essential to animals such as selenium and iodine (Hunt 1994). A deficiency of copper has been reported to be associated with the range of developmental orthopaedic diseases (Grace 2005, Jeffcott 1996, Hurtig *et al.* 1993, Knight *et al.* 1990).

Developmental Orthopaedic Disease (DOD), is the most widely accepted term used to include all skeletal problems associated with growth and development in young horses. It includes osteochondrosis, subchrondral cystic lesion, physitis, angular limb and flexural deformities, cuboidal bone malformations and wobbler disease (Jeffcott 1996). Periods of rapid growth are thought to be associated with the expression of (DOD), in particular osteochondrosis (OCD) (Firth *et al.* 1999, van Weeren *et al.* 1999, Pagan & Jackson 1996).These skeletal complications which occur in periods of rapid growth are undesirable and can impact the sale and indeed the value of the equine product.

Published data shows that that growth rates from foals reared on pasture in NZ were comparable to growth rates of foals reared in grain-based systems in the Northern Hemisphere (Brown-Douglas & Pagan 2009, Morel *et al.* 2007). Table 2.4 is a summary of published research showing the mean bodyweight (kg), of foals born in the spring or autumn in New Zealand, and foals born in the spring in the northern hemisphere. (Brown-Douglas *et al.* 2005).

Table 2.4: Mean bodyweight of Thoroughbred foals born in NZ (autumn and spring), and in the Northern Hemisphere (spring).

Table 2. Comparison of mean bodyweight (kg) between foals in the present study born in either spring or autumn, and foals born in the spring in the Northern Hemisphere.

	Bodyweights (kg) at different ages (months)				
Study	**n**	**1**	**2**	**6**	**12**
Spring-born	56	104	144	253	362
Autumn-born	7	99	141	257	372
Hintz et al (1979)	1,992	97.5	136	240.5	337
Thompson (1995)	106	99.4	133.6	258.5	363.9
Jelan et al (1996)	798	–	131.5	240.5	340.0
Pagan et al (1996)	350	–	–	253.3	342.2

At 18 months of age Australian and NZ Thoroughbreds generally tended to be heavier and taller than American Thoroughbreds, which were larger than those Thoroughbreds reared in England (Brown-Douglas & Pagan 2009). Data from Pagan *et al.* (1996) and Morel *et al.* (2007), supports the assumption that the average daily gain (ADG) decreases linearly as live weight (LW) increases. The growth of Thoroughbred foals is considered to be biphasic, with period of rapid growth until weaning at approximately 4-5 months of age, after which the GR decreases to approximately two-thirds of the pre-weaning rate (Morel *et al.* 2007).

The National Research Council (NRC) nutrient requirements for horses (Table 2.5, Anonymous 2007) are widely accepted, however it must be noted that the published data are sourced from horses fed conserved forage and grain-based diets which is in direct contrast to the New Zealand pasture based farming system. The daily requirements have been calculated using assumed feed intakes of 2.5% BW (DM) for lactating mares and growing horses and 2.0% of BW (DM) for all other classes. These daily requirements are considered to be the minimum requirement for each stage (Table 2.5), (Anonymous 2007). Intake is a function of the DE requirements and the DE concentration of the feed.

Table 2.5: National Research Council daily nutritional requirements of Horses, (Anonymous 2007), mature body weight 500 kg.

Horse Class	Weight (kg)	ADG Daily gain g/day	Requirement: Energy MJ DE/day	MJ DE/kg DM	Crude Protein (CP) g/kg DM or (g)
Maintenance	500		70	7	60 (530)
Pregnant mare					
9 months	534	410	80	8	80 (797)
11 months	566	650	89	8.9	89 (893)
Lactating mare					
Foaling to 3 months	500		133	10.6	121 (1511)
3 months to weaning	500		123	9.8	109 (1365)
Growing horse					
Weanling, 4 months	168	840	56	13.3	152 (669)
Weanling, 6 months	216	720	65	12.0	125 (676)
Yearling	321	450	79	9.8	104 (846)
Two year old					
Not in training	429	180	78	7.3	68 (770)
In training	429	180	110	10.3	84 (944)
Stallion					
Non breeding	500		76	7.6	72 (720)
Breeding	500		91	9.1	79 (789)

A comparison between the recommended nutrient requirements (Table 2.5), and the nutritive content of pastures, (Table 2.6) shows the likely feeding value of pasture in New Zealand. With respect to the nutrient recommendations there are likely to be differences between grain based diets (Anonymous 2007),and pasture in terms of digestibility, and the bioavailability and utilisation of nutrients.

The data available are not exhaustive but do show seasonal changes in the components of nutritive value of pasture, (energy and crude protein). There is a lack of data which compares the seasonal nutritional quality, particularly for neutral detergent fibre, (NDF), acid detergent fibre (ADF), soluble starch and sugars, (sol CHO) and organic matter digestibility, (OMD).

Table 2.6: Nutrient content of pasture.

	Content			
	Energy	CP	NDF	Soluble CHO
Pasture	MJ DE/kg DM	g/kg DM		
NZ Ryegrass + white clover pasture				
- Autumn[123]	10.8	222-254	386-418	68-76
- Winter[12]	11.4-11.2	222-268		
- Spring[123]	10.8-11.8	148-220	432-494	71-112
-Spring (leafy)[123]	12.0	220-236	438	85
- Summer (leafy)[12]	10.3	150-219		
- Summer (stalky)[12]	8.0	100		
North America				
Grass pasture cool season, veg.[4]	10.0	26.5% DM	45.8% DM	
NZ Red Clover grass				
Pre-bloom[12]	11.0	230		
Full-bloom[12]	10.0	180		

[1]Hoskin&Gee (2004); [2] Hunt (1994); [3] Grace N (2005), [4]NRC Anonymous (2007).

A comparison of the data of nutritional requirements of the horse from Table 2.5, which are based on studies from temperate North America, NRC to Table 2.6, reveals that ryegrass-based pastures in New Zealand have a high digestible energy (DE) and crude protein (CP) content, which are in excess of dietary recommendations as published by NRC (Anonymous 2007), (Hoskin & Gee 2004). The energy and protein intakes of growing horses are the factors most likely to influence the foal's growth rate, (GR). Other nutrients are known to influence the growth rate, but their effects are more difficult to quantify (Hintz 1979).

The quantification of the quality and composition of the pasture during each herbage growth cycle will allow for the accurate and optimal use of both pastures and supplements when formulating balanced diets for horses, optimising growth and minimising wastage due to growth and nutrient related orthopaedic problems.

2.3 The equine production system in New Zealand

The horse breeding industry in NZ is comprised of three major enterprises including the Thoroughbred, Standardbred and Sport horse breeding entities. Table 2.7 illustrates the two largest breeding enterprises in NZ. Data from 2008 reports an approximate horse population in NZ of around 120 000, with 35% of these being Thoroughbred (Anonymous 2008b).

The equine industry in NZ makes a significant contribution to the NZ economy in terms of output, gross domestic product (GDP), and employment. During the 2007/2008 season the NZ racing industry generated more than $1.5 billion annually in 'value added' product and services to the local economy (equating to 1.3% of NZ's annual total GDP). Of this, 73% was generated by TB racing, whilst 22% was generated by SB racing (Anonymous 2008b).

Table 2.7: Registered mares, foals and stallions in New Zealand from the respective breed organisations.

	Season	Broodmares at pasture	Foals Born	Stallions standing	Horses exported
Thoroughbred	2007-2008	8048[1]	4126[1]	177[1]	1577[1]
Standardbred	2006-2007	4100[2]	2790[2]	90[2]	610[2]

Notes: [1]Anonymous 2008b, [2]Anonymous 2008a.

A third, much smaller group of commercial breeders are involved with the breeding of sporthorses or performance horses for the equestrian disciplines, of which currently little co-ordinated published information regarding the numbers exists.

The principal aim of all three systems is to maximise the genetic potential of the horse with the production of a healthy sound athlete, capable of achieving excellence in its respective sporting code. While the management systems between these enterprises have their differences, the one thing they all have in common is the almost total reliance on pasture to supply broodmares, young growing and spelling horses with sufficient nutrients to support maintenance, growth and reproduction.

Typically the equine production system in NZ is based around periods of high stocking density during early spring to late summer. Pasture management during these periods is often overlooked due to the operational pressures of a stud farm as a result of foaling mares, re-breeding, followed by yearling sales preparation followed by weaning in late summer/early autumn. The stocking density during this period is generally at the expense of the persistence of desirable pasture plants and overall pasture quality.

The following sections will outline the two largest equine breeding systems in NZ, the Thoroughbred (TB), and Standardbred (SB), systems.

2.3.1 The Thoroughbred industry in New Zealand

The NZ Thoroughbred industry is heavily export focused with the equivalent of around 40% of the Thoroughbred foal crop exported each year, in 2007 (n=1,577) horses were exported. It also makes an important contribution to the local economy in terms of employment, during the 2007-2008 season there were some 13,500 fulltime employees supported by employment in the NZ Thoroughbred industry (Anonymous 2008b).

While the aim of most breeders is to produce a healthy and durable racehorse, most commercial operations are concerned with the breeding of quality stock aimed at the annual yearling sale market. The TB yearling sales provide the first opportunity along that pathway to measure and realise business success. There is pressure to grow youngsters at a rate which ensures they are larger at the yearling sales (maximising growth as opposed to optimised growth). According to data examined by Pagan *et al.* (2009), yearlings that commanded bids higher than the median price of the sale session in which they were sold, tended to be heavier (when measurements were adjusted to account for age and gender effects), but not fatter than yearlings receiving bids below their session's median price (Pagan *et al.* 2009). The ideal condition score for a sales yearling is 6.0 on a scale from 1 to 9, and yearlings presented for sale with lower condition scores are less likely to meet the sellers' expectations (Pagan *et al.* 2009).

Proportionally the largest number of Thoroughbred properties are located in the Waikato region with smaller pockets of large commercial studs found NZ-wide. The distribution showed that most of the Thoroughbred breeding farms are found in the Waikato region in greater numbers than in the Auckland region followed by the Manawatu, Canterbury and Wairarapa regions. The least number of breeding farms were found in the Otago region (TB breeders' website).

The breeding operation for TB breeding farms is limited to natural cover so mares are shipped to the stud to foal and be subsequently re-bred. The stocking density on most TB breeding farms is at a high level during the early spring to late summer period when client's mares and foals are present (Goold 1997). Some mares will leave the stud farm following a positive pregnancy test, however some will remain at the stud until weaning, leaving the main stud during the winter period. Most studs have a core band of broodmares which remain on the stud farm all-year around.

2.3.2 The Standardbred industry in New Zealand

The Standardbred (SB) industry is smaller than the TB industry, with approximately half the number of registered broodmares, (n=4,126 (TB), n=2,790 (SB), (Anonymous 2007a, Anonymous 2007b). The number of Standardbred breeding farms found in the Canterbury region are greater than, Southland which is greater than in the Auckland region, followed by the least number in the Waikato region (HRNZ website).

The SB breeding industry is less reliant on the export of horses with the equivalent of approximately 20% of its foal crop (n= 600) exported during the 2006/2007 season, by comparison to the TB industry (Anonymous 2007a). There is less focus on producing horses for an annual yearling sale than for the TB industry, and more on producing race horses for the domestic market. The SB industry statistics show a decline in the numbers of foals born in the 2001/2002 season (3,400) through to the 2007/2008 season (2,800 foals). Exports have declined during the same period from 850 to 600 horses (Anonymous 2007a), and mare numbers dropped from almost 5,000 registered to around 4,000. However, starters increased during the same period from around 3,100 to 3,500 horses (Anonymous 2007a).

The SB breeding farms in NZ differ to the TB breeding farms because their breeding operation allows the use of artificial insemination (AI). Many of these operations tend to be large studs which operate as breeding centres offering services to both their own stallions and stallions in different parts of the country (fresh chilled shipped semen), and worldwide (frozen semen). As with the TB industry there are also a number of smaller SB breeders spread across NZ. However, due to the convenience of AI and the ability to use shipped semen many choose to retain their own mares, rather than sending the mare to the stallion for live cover.

Similarly to the TB breeding farms, SB farms also experience a seasonal period of high stocking density. Many of the larger breeding centres receive outside mares for foaling and re-breeding during the busy spring and early summer period. Again most SB studs have their own band of core broodmares which remain on the main stud farm all year around.

2.4 Pasture composition and production

2.4.1 Pasture composition

Equine pastures in New Zealand typically consist of a mix of grasses and legumes (Hunt 1994), with a degree of weed present, which is largely dependent on the level of pasture management. The pasture species found on equine breeding farms in New Zealand are a result of historical planting for the sheep, beef and dairy production systems (Table 2.8), rather than forage types which have been scientifically proven and selected as a forage type appropriate for an equine production system. Table 2.7 shows the species that could be found in any New Zealand pasture, which could include the following grasses, legumes, pasture herbs and weeds. Perennial ryegrass-based pasture in New Zealand generally comprises approximately 80-95% perennial ryegrass and 5-20% white clover (Hoskin & Gee 2004).

In terms of equine pasture grown in New Zealand the most important cool-season grass species are; ryegrasses (*Lolium perenne* and *Lolium multiflorum)*; timothy (*Phleum pratense*), cocksfoot (or orchardgrass; *Dactylis glomerata*), tall fescue (*Festuca arundinacea*) and browntop (*Agrostis.*spp) (Templeton 1979, Hoskin & Gee 2004). Warm-season grasses include paspalum *(paspalum notatum,* and kikuyu *(Pennisetum clandestinum).* White clover (*Trifolium repens*) is the most widely used legume in pasture mixes for horses in the USA(Smith *et al.* 1986).

Table 2.8: Pasture – Botanical Composition in New Zealand.

Grasses	Legumes	Pasture Herbs
Perennial Ryegrass	White clover	Chicory
(*Lolium perenne*)	*(Trifolium repens)*	*(Cichorium intybus)*
Italian Ryegrass	Red Clover	Sheep's burnet
(Lolium multiflorum)	*(Trifolium pratense)*	*(Poterium sanguisorba)*
Hybrid Ryegrasses	Lucerne	Plantain
(Lolium x)	*(Medicago sativa)*	*(Planta golanceolata)*
Tall fescue	Lotus	Dandelion
(Festuca arundinacea)	*(Lotus uliginosus)*	*(Taraxacum officinale)*
Cocksfoot (orchardgrass)	Subterranean clover	Yarrow
(Dactylis glomerata)	*(Trifolium subterraneum)*	*(Achillea millefolium)*
Phalaris		
(Phalaris aquatica)		
Prairie Grass		
(Bromus willdenowii)		
Grazing brome grass		Weeds
(Bromus stamenius)		
Smooth and upland brome		Oxeye daisy
(B. sitchensis & B.inermis)		*(Leucanthemum vulgare)*
Kentucky Bluegrass		Dock
(poa pratensis)		*(Rumex obtusifolius)*
Timothy		Californian thistle
(Phleum pratense)		*(Cirsium arvense)*
Browntop		Chickweed
(*Agrostis.*spp)		(*Stellaria media*)
Yorkshire fog		Mellow
(Holcuslanatus)		(*Malva*sp.)
Paspalum		Buttercup
(Paspalum notatum)		*(Ranunculu ssp.)*
Kikuyu		Penny Royal
(Pennisetum clandestinum)		*(Mentha pulegium)*
Annual Poa		
(Poa annua)		

2.4.2 Pasture production

For pasture, the seasonal effects and pasture management practices both have the ability to change the ratio of the species found at any given time (Hunt 1994, Grace 2005, Waghorn & Clark 2004). The soil type, climate and management of the pasture all have an effect on which plants thrive, which persist or fail to persist under particular environmental conditions. The major factors attributing to pasture quality and growth are temperature and rainfall which influence the dry matter (DM) production (Grace 2005). Pasture quality and growth is highly seasonal, especially in the warmer regions of New Zealand. In the absence of drought generally it is the quality of pasture that sets the limit on animal performance over summer and autumn (Litherland & Lambert 2007).

In NZ, typically the greatest pasture growth is during October – November where approximately 60 kg DM/ha/day is produced whereas during winter this reduces to around 14 kg DM/ha (Grace 2005). The quality and quantity of available pasture is best during spring. Consideration of the supply of pasture DM in combination with the DM requirement of the horse needs to be matched, to allow for the determination of a suitable stocking rate and ultimately to predict seasonal shortfalls in supply of pasture DM.

The data in Figure 2.3 are based on a mean annual pasture production of 11500 kg DM/ha (Grace 2005). The daily DM requirement of the following horse classes according to Grace 2005 are as follows; broodmare 13.6 kg DM/day, weanling 5.5 kg DM/day, and yearling 6.8 kg DM/day to ensure adequate milk yields and good growth rates. These values were calculated based on pasture analyses and NRC tables (Grace 2005).

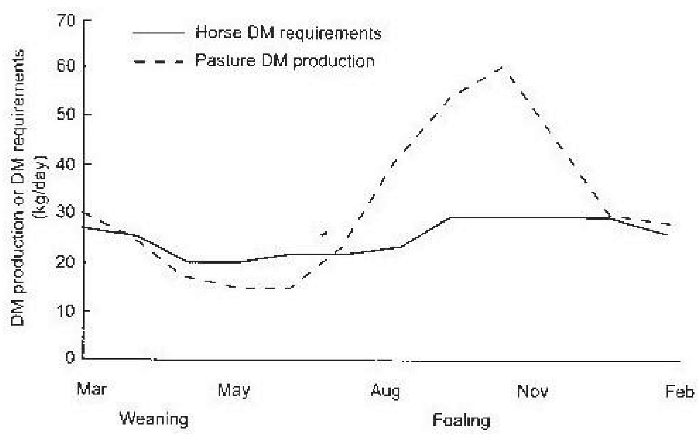


Figure 1. Relationship between daily pasture DM production and daily horse DM requirements. Stocking rate of 1.5 mares and their foals per hectare.

Figure 2.3: Association between daily pasture DM production and daily horse DM requirements, (Grace 2005).

The most critical period for an adequate supply of pasture is in the winter period where pasture DM production drops below the horse's DM requirements, (Figure 2.3). Depending on the seasonal growth during late spring and summer, the potential for feed shortages is also possible, particularly as pasture quality declines in combination with the drop in supply levels. Pasture availability during these seasons is very much affected by the climate in combination with stocking rates and pasture management. Supplementary feeding of conserved forage (hay, baleage/haylage) is commonplace during periods of feed shortages.

Stocking rates and seasonal extremes will have the most influence over the requirement for the level of supplementary feed required during any period of shortfall. Stocking rates also have the ability to affect the botanical composition of the pasture (Popp *et al.* 1997), with heavily stocked horse pastures being detrimental to certain species, an effect further exacerbated by the horses' selective grazing behaviour.

Horses are notoriously demanding on pasture which brings added challenges to maintaining the nutritive value at a high level. They are reluctant to graze in areas which contain faecal contamination, which continues long after the faecal pat has disappeared. This creates patches of overgrazed 'lawns' and roughs containing under-grazed rank pasture. This is also due in-part to low stocking rate for horses.

On most large equine properties the dung pats are historically spread out periodically by the use of chain harrows. The other way to avoid the creation of these rough dung concentrated areas is by complete removal of the manure. This is a highly labour-intensive process so it is unlikely to be carried out on large properties, particularly in the larger paddocks away from the main office and buildings. Even with 100% manure removal from the rough areas, in places where the horses have urinated roughs do develop, albeit a little more slowly. The complete removal of manure can reduce the exposure of the horse to parasites, however removing the manure completely excludes the natural form of fertiliser to the ground so fertiliser of some description needs to be added back to promote good soil health.

The selective grazing behaviour of horses' results in the undesirable/uneaten pasture plants eventually becoming dominant in the sward (Grace *et al.* 2002b). This is largely because horses have a tendency to return to the same preferred feeding site until it is overgrazed (Kruger & Flauger 2008). This uneven grazing habit eventually reduces 'actual' grazing area if not managed - limiting total pasture utilisation. Pasture utilisation for cattle has been reported at 80%, whereas mares and foals are around 50% (Goold *et al.* 1988). Breeding managers must consider the pasture area which is actually available for grazing and the consequences this has on the most appropriate stocking rates for horses in any given property (Wallace 1977).

2.4.3 Equine pasture quality and seasonality

The potential value of a diet is best expressed as feeding value, (FV) which is defined as nutritive value (NV) x intake (Waghorn *et al.* 2007, Ulyatt 1981). However, this is a definition developed for ruminant production which may not be necessarily appropriate in an equine context (Hoskin & Gee 2004). *Ad libitum* intake is affected by feed quality (NV), so the terms NV, intake and FV are interrelated and interdependent (Waghorn *et al.* 2007). The NV is a measure of a diet's ability to meet animal requirements for maintenance and production.

The NV is a function of the nutrient content and the digestion and subsequent utilisation of digested nutrients for body functions (Hoskin & Gee 2004, Waghorn & Clark 2004). NV can indicate the potential for animal productivity, however it is difficult to accurately predict production, which is affected by the DM intake, the chemical and mineral composition of the DM, and the products of digestion and the utilisation in the animal's tissues (Waghorn *et al.* 2007, Huntington P *et al.* 2005). The factors affecting the DM intake of the horse are: its physiological state, its dietary preferences, the pasture height, the nutrient density of the forage, the forage availability, and the environmental conditions. The chemical and mineral composition of a feed is affected by seasonal and environmental factors.

In general, factors affecting the NV of forages for ruminants, (Waghorn & Barry 1987; Waghorn & Clark 2004), appear largely true for horses, including a decrease in NV of forages with increasing plant maturity (Darlington & Hershberger 1968, Hoskin & Gee 2004). It is proposed that the horse is able to maintain themselves on herbage that is more fibrous than a similar sized ruminant is able (Janis 1976). It is well known that digestibility declines with forage quality (Duncan 1980). However for intake, most studies have found no significant relationship relating to forage quality (Edouard *et al.* 2009). Individual horses showed that they could increase their intake as forage quality and digestibility declined, but not all individuals responded in the same way for all forages. However, for those horses fed grass forages it was found that most individuals did respond at least partially to a decline in forage digestibility by increasing their voluntary intake differing to cattle where intakes decline on poor-quality forages. The researchers concluded a possible explanation was that individual horses responded differently to a decline in forage quality, because they were selected on the basis of athletic ability rather than meat or milk production in the case of the ruminant, (Edouard *et al.* 2009).

Recent research also shows that sward height affects forage selection and ingestive behaviour in horses, independently of the variations of the nutritive values of forages (Edouard *et al.* 2009). The horses choose between vegetative patches of a good and similar quality forage and according to predictions from optimal foraging models they selected the one that they could ingest faster (maximal DM intake). What is not clear from this experiment is how the horses adapt their feeding behaviour when they are faced with a trade-off between sward height and quality. This type of experiment is confounded with several issues regarding sward height and the variability of fibre content, particularly due to seasonal effects, and the species of the grass (some are more palatable to horses). If anything could be taken it is that horses will tend to ingest a taller sward in preference to a shorter one, to maximise DM intake. The determination of what actually constitutes 'quality' pasture for horses is poorly understood and tends to be extrapolated from ruminant studies.

Data gathered on sheep and beef farms, across several regions in New Zealand, in seasonally distinct periods by Litherland *et al.* (2002), (see Figure 2.4), show the trends which are observed for botanical composition compared to ME (MJ ME/kg DM) and also for CP, lipid, ADF,NDF and soluble carbohydrate (sol CHO).

FIGURE 1. Seasonal pattern of offered pasture composition (dead, clover + herbs, green grass leaf, green grass reproductive stem) and energy (ME) content on commercial sheep and beef farms in four regions

FIGURE 2. Seasonal pattern of chemical composition of pasture plucked to simulate animal intake on commercial sheep and beef farms in four regions.

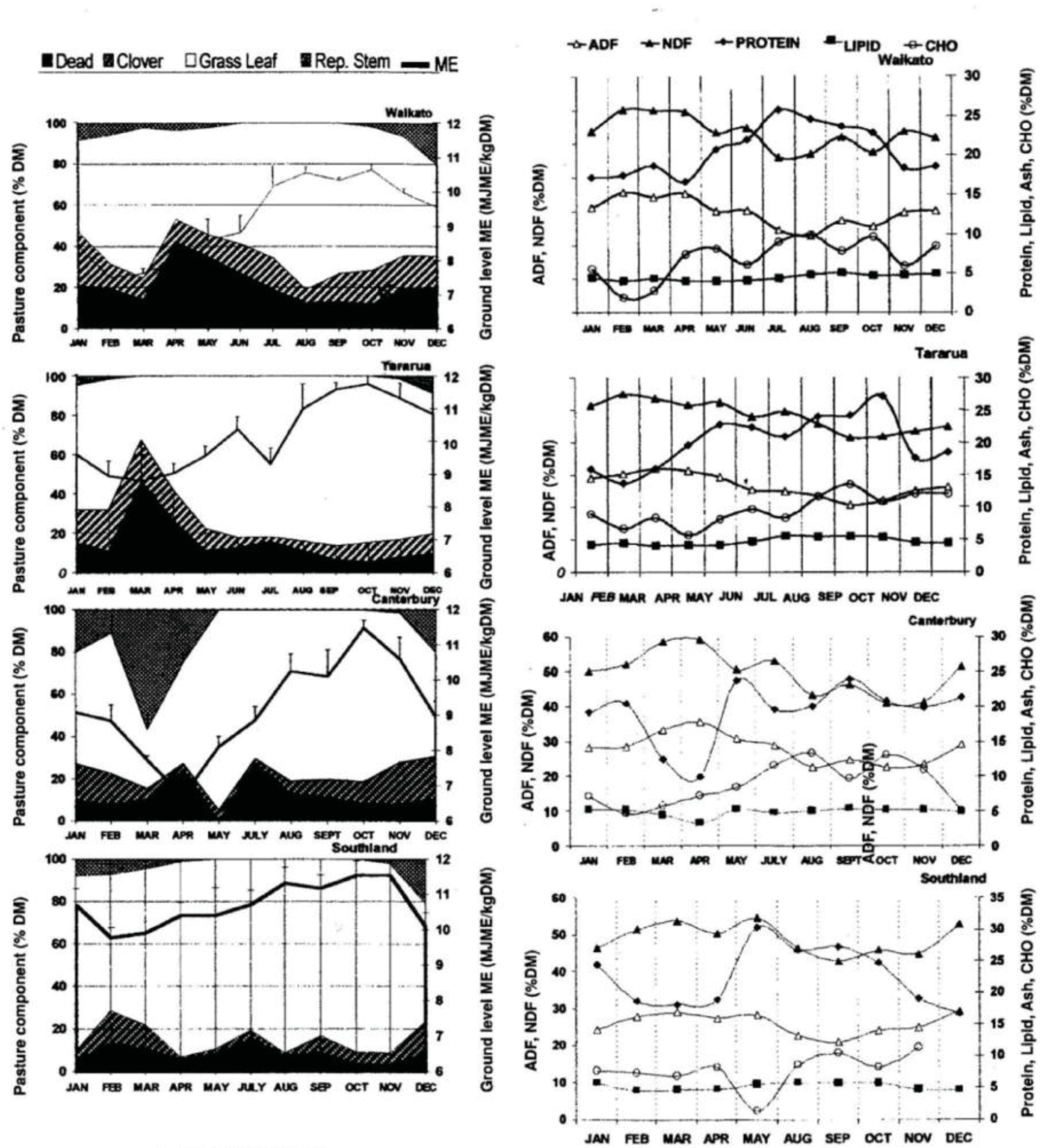


Figure 2.4: Seasonal pasture quality, Litherland *et al.* 2002.

The data from the study detailed pasture quality over one calendar year only, and variations in climate will affect the magnitude of pasture changes between years (Litherland *et al.* 2002). For the year-long pasture study the ME content of pastures tended to be highly seasonal with more pronounced effects in northerly regions.

Pasture energy levels declined after November, as dead matter and stem content increased (Litherland *et al.* 2002). ME concentrations increased during winter to reach a peak in spring. The pattern of quality for sheep and beef pastures followed similar seasonal changes as to those reported for dairy pastures (Moller *et al.* 1996). The decline in ME during summer was associated with an increase in dead matter accumulation (Litherland *et al.* 2002). Increasing photoperiod in late spring triggers reproductive grass growth which if left uncontrolled, can lead to a residue of low-quality stem material in autumn that further lowers ME (Waghorn & Barry 1987). The quality of green grass leaf is also lower in autumn than in spring (Litherland *et al.* 2002). Wilson & Ford (1973) recorded a drop of 1 MJ ME/kg DM in temperate grass leaf grown at 30°C, compared with leaves grown at 20°C which would account for the slightly higher ME of the leaves grown in spring versus a warm autumn. Under New Zealand conditions (in northern regions), the difference is likely to be smaller since they experience less variability in overall temperature.

Pasture quality is dependent on the ratio of cell contents to cell walls and cell wall digestibility (Litherland & Lambert 2007). The amount of dead matter in the pasture is the main determinant of pasture quality. Pastures which have been poorly managed resulting in high levels of dead matter and reproductive stem content in addition to those under seasonal pressure in summer will be of less quality and lower ME. Management during these periods is crucial to maintaining pastures of high quality for as long as possible, before climatic conditions have a greater influence over forage quality.

Crude protein levels in New Zealand pasture based diets is largely in excess of animal requirements, so the ME concentration of the pasture largely determines its quality, (Litherland & Lambert 2007). In NZ pasture ME concentration rises over winter and reaches a peak in spring, quality begins to drop around November (earlier in warmer regions, later in cooler regions) to reach a low in February/March as dead matter reaches a peak level. Litherland & Lambert (2002), found the trough in quality to be lower in warmer environments. Following autumn rains, new growth occurs and dead matter breaks down and quality rises, until it reaches winter levels again.

The following discussion covers the management of equine pasture in New Zealand and the analysis of the nutritional composition of that pasture. Best practice pasture management and information regarding the nutritional quality of pasture will serve as tools from where to base the selection and subsequent provision of correctly balanced diets for valuable bloodstock.

2.4.4 Equine pasture – pasture management

For most commercial equine properties in New Zealand there is an extended period during the year where extraordinary stress is placed on the pasture, with stocking rates in excess of normal levels, (Goold 1991). This is an inevitable part of the business operation. These farms substantially increase stock numbers on a seasonal basis, e.g., by taking in outside mares to foal; then re-breeding those mares; before finally weaning the foals and returning them to owner/s and/or turnout grazing off the main breeding unit for the remainder of the year.

The period from September through to late spring/early summer is where the greatest pressure on stocking rate occurs. The latter part of this intense stocking rate also coincides with the period which can be limiting in terms pasture production and quality. Data from Table 2.9 clearly shows the much higher demands horses place on pasture than sheep, where one breeding ewe is the equivalent of 1 stock-unit (SU), by comparison to the horse which can equate to 6-14 Stock units depending on age and physiological status (Goold *et al.* 1988). The concept of the ewe-equivalent was established by Coop (1965), with various modifications since (Nicol & Brookes 2007). It is intended as a measure of the carrying capacity of farms for different classes of livestock.

Table 2.9: Data taken from Code of recommendations and minimum standards for the welfare of horses. (1993).

Class of livestock	Stock Unit (SU)
Breeding ewe	1
Two-year old steers (May)	6
Adult horse/ mare	13
Mares and foals	14
Weanling (March-April)	6
Yearling (January)	13

A new revised stock unit (RSU), proposed by Nicol & Brookes (2007) shows that the original Coop ‘standard ewe’ is related to the annual digestible organic matter requirement of the animal, which is close to 6000 MJ ME. Theoretically according to NRC (2007) the annual DE requirement of a horse would range from 70 – 133 MJ DE/day, (annually 25550 - 48545 MJ DE), (Anonymous 2007). If 18% is subtracted from the DE requirement (to account for losses in urine and methane gas) it gives an approximate annual ME requirement of 21000- 40000 MJ ME for the horse, depending on its physiological stage. It is then possible to calculate that a horse (depending on its physiological stage), would a have a RSU of 3.5 (maintenance adult horse) up to a RSU of 7 for a lactating mare with a foal aged birth to 3 months of age. These calculations are based on information from NRC (Anonymous 2007) and Nicol & Brookes (2007). The RSU gives a lower value, by comparison to the historical SU data in Table 2.9, however how the published data regarding the SU in the NZ code for the welfare of horses does not reference how these values were obtained (MAF 1993).

It is possible to maximise the amount of pasture DM by the use of suitable pasture management techniques. The range of these management practices can include the enhancing soil fertility by the application of solid and/or liquid fertilisers and the renewal of pasture species to more productive persistent varieties. Practices such as topping will keep the pasture in the leafy stage for as long as possible during the growing season. The use of cross grazing with other stock can also enhance the quality of the pasture; by consuming excess pasture; the non-selective grazing pattern and the re-distribution of nutrients to the pasture.

De-foliation and overgrazing of desirable pasture species during periods of overstocking serves to open up the pasture and encourage the growth of weeds, most of which are undesirable to horses and tend to flourish if not managed correctly. The practice of closing paddocks to produce a heavy sward of saved pasture generally fails due to the deterioration of the plants, especially at the base and the poor recovery following grazing (Wallace 1977). According to Goold (1997), pasture offered to horses should be grazed at a height of 20cm down to a height of 8cm. Overgrazing results in the loss of high fertility grasses like perennial ryegrass from the preferred grazing areas (Goold 1991). Horses will graze high-sugar grasses, such as ryegrass in preference to other grasses such as timothy, browntop and fescue (Hunt 1994).

Pasture management can play a role in assisting in the reduction of some of these problems by cross-grazing with other species such as cattle or sheep. Cattle and sheep assist in maintaining an even height in the sward and ensuring the grass/pasture plants which are not palatable to horses don't become dominant in the sward. Cattle and sheep also re-distribute nutrients necessary for healthy pasture growth by virtue of the fact they eat the rank growth and the distribution of their faeces and urine is indiscriminate (Wallace 1977). Sheep are probably a better combination with horses as they are more indiscriminate than cattle regarding the re-distribution of nutrients. However, the use of sheep on equine properties is not always practical as they require a different fencing design than is often found on most breeding farms. It is important to note that fertility transference in the pasture is not easily solved, particularly for those properties which have very high stocking densities (Goold 1991).

The management of horse pastures with regular soil fertility tests is critical to providing an environment where productive and desirable pasture species can flourish, ensuring animal health and production is not compromised. Pasture renewal is also an important part of overall management ensuring that optimum forage quality and growth rates are achieved. New modern varieties of grasses are generally faster growing producing more DM per hectare than their older counterparts. Soil fertility combined with a regular programme of grass renewal has an important role to play in ensuring that the most productive grasses dominate and that animal production isn't compromised by soil fertility problems and low yielding pasture plants.

Therefore understanding the principles of maintaining pasture quality and the growth rate which can be expected during any season will provide the necessary information to modify grazing management to achieve the maximum possible quality (Litherland & Lambert 2007). However, despite the best management there are always going to be constraints on quality, largely imposed by perennial ryegrass maturation and aging, and the interaction with temperature, which cannot be overcome. The solution is to be aware of periods where pasture is limiting for animal performance and ensure there is provision of an adequate supplementary feed supply to counteract this deficit (Litherland & Lambert 2007).

2.5 Pasture quality assessment

The nutritional analysis of pasture allows for diet selection to be more accurate, particularly during periods when pasture nutrition is limiting for animal performance.

Pastures must be well managed and maintained to preserve their nutritive value because once they become long and/or rank and mature the concentrations of various plant components change and the nutritive value decreases, (Grace *et al.* 2002b). Soluble sugars and CP decrease by 20-25%, while cellulose, hemicellulose and lignin increase by 19-25% as the plant matures (Waghorn & Barry 1987).

High levels of animal performance and health are dependent on the provision of high quality nutrition and management (Corson *et al.* 1999, Sirois 2001). Since nutrition often limits the productivity of ruminants (Ulyatt & Waghorn 1993, Corson *et al.* 1999) it is likely the situation is the same for horses given they also have specific nutritional requirements for growth, reproduction and overall health.

2.5.1 Pasture – botanical composition

The determination of botanical composition of the pasture provides insight into the most dominant pasture species at any given time. Pasture is collected with the aim of simulating the grazing activity of the livestock. Botanical composition is determined by dissecting each pasture sample into ryegrass, other grasses, clover (legumes), weeds and dead matter (Adu *et al.* 1988). Adu *et al.* (1988) dried samples separately at 100 °C for 18-24 hours once dried were re-weighed to determine botanical composition as a % of DM.

2.5.2 Pasture – chemical composition

Livestock farmers are aware of the importance of obtaining quantitative information about the quality of the diet they offer to their animals in an efficient and cost-effective manner (Corson *et al.* 1999). Conventional chemical analysis is expensive and time consuming by comparison to Near Infra-Red Spectroscopy, (NIRS) analysis. With the development of NIRS technology, efficient and cost effective predictive analysis is available to pasture managers.

NIRS is a rapid non-destructive and inexpensive technique for predicting chemical and nutritional analyses of feedstuffs (Corson *et al.* 1999, Roberts *et al.* 2004, Sirois 2001, Stuth *et al.* 2003). NIRS can determine the amount of structural carbohydrate, crude protein, lipid and ash and it can also predict the digestibility and metabolisable energy (ME) value of a feed (Ulyatt *et al.* 1995). NIRS is used widely to balance rations for dairy cattle and is recognised by the Association of Official Analytical Chemists (AOAC) as an official method (Sirois 2001).

NIRS analysis involves a 0.5-1.0 g sample being exposed to an electro-magnetic scan over a spectral range of 1100 to 2500nm, (near infrared). Energy in this spectral range is directed onto the sample and reflected energy (R) is measured by the instrument. The diffuse reflection carries information which identifies chemical bonds within the sample, such as – CH, -OH, -NH and –SH. The reflected energy is stored as the reciprocal logarithm, ($\log {}^{1}/_{R}$) and the spectra are transformed to provide information about the chemical composition of the pasture (Corson *et al.* 1999).

Sample collection is a critical part of the pasture analysis. Sirois (2001) recommends that the key to sampling pasture is sampling at multiple sites. To simulate grazing intake, a random selection of 12-20 sites would be plucked at grazing height where the animals have been grazing. All sub-samples should be combined and mixed thoroughly so that it is representative of the pasture being analysed.

Grazing height is the level at which the animals are consuming – for longer pasture, animals only consume the top portion (maximal DM ingestion), while pastures with less cover will be grazed more closely to the sward base. Horses generally graze the sward at a lower height than ruminants, but in the case of access to longer pasture, (plentiful supply) they will consume the top leafy portion of the sward. Consideration of pasture cover at the time of sampling will dictate the sampling level to reflect the actual nutrition the animal is likely to be receiving.

2.6 Conclusion

Pasture, both in quality and quantity is a key asset to the equine production system in NZ and should be managed with this in mind. The main objective should be to utilise the pasture asset fully, by providing a high-quality forage for grazing bloodstock with less reliance on supplementary feeding. Clearly this is not always going to be possible on heavily stocked properties given the seasonal nature of the equine farming system, especially in those periods where pasture growth is limiting. There is also a long-time dependence of supplementary feeding of bloodstock which typically does not occur to the same extent on traditional production systems. Although, the dairy industry is becoming increasingly reliant on off-farm feeds as stocking rates and high genetic-merit cows demand more feed than can be grown from pasture alone.

It is clear from the review that published information regarding the seasonal nutritional quality of pasture available to bloodstock across NZ is scarce. Given that the temperate climate of New Zealand allows bloodstock to be almost exclusively grazed on pasture year-round, understanding of the seasonality and year to year variation of pasture production will assist in the future optimisation of pasture and nutrition for grazing bloodstock in New Zealand.

Chapter 3
Seasonal pasture quality on commercial Thoroughbred and Standardbred farms in New Zealand: the chemical and botanical composition of pasture

3.0 Introduction

Horses are large, non-ruminant herbivores which evolved primarily as grazers of high fibre pasture (Hoskin & Gee 2004). In their natural environment horses will graze for long periods and cover some distance each day (Duncan 1980). Feral horses in Australia cover around 15.9± 1.9 km/day (with a range of 8.1-28.3 km/day), and even in the domestic environment horses will cover approximately 9km/day (Hampson *et al.* 2010). In their natural environment, horses have been recorded up to 55 km from their watering points and some horses walked for 12h to water from feeding grounds (Hampson *et al.* 2010).

In New Zealand, pasture provides the majority of the nutrition for broodmares and foals, and horses used for recreational purposes. However, horses on Thoroughbred and Standardbred farms often have a much higher proportion of their nutritional requirements met with the feeding of pre-prepared commercial formulations or grain based rations, rather than from pasture alone (Stowers *et al.* 2010, Rogers *et al.* 2007). In some situations this can lead to a substitution effect, with up to 60% of the horses daily ME requirements being met from cereal-based concentrates, resulting in possible under utilisation of pasture (Stowers *et al.* 2010).

Within the commercial equine production system there is often significant pressure to feed cereal based rations to horses in order to maintain sufficient rates of growth and development, yet studies have shown that a satisfactory growth rates in Thoroughbred young-stock can be achieved from the consumption of pasture alone (Brown-Douglas *et al.* 2005). The levels of macro nutrients available in New Zealand pasture are generally acceptable, however, NRC (2007), recommendations for Cu, Zn, and Se and how that additional supplementation for these nutrients may be required for horses grazing pasture alone (Grace *et al.* 2002a).

The provision of a diet which is correctly balanced to meet optimised growth is desirable since periods of rapid growth and/or mineral imbalances are thought to be associated with the range of developmental orthopaedic disorders (DOD), in particular osteochondrosis (OCD), (Pagan & Jackson 1996, Firth *et al.* 1999, van Weeren *et al.* 1999). However, DOD is a multi-factorial disease and its expression is also influenced by other factors such as genetic predisposition.

In NZ access to pasture should be considered an asset to the commercial equine system, as there are a number of health benefits to be gained as a result of horses being primarily pasture-raised (Hoskin & Gee 2004). In addition to the nutritional benefits of horses kept at pasture, it is also advantageous for them to be grown in an environment where they can express natural grazing behaviour. Horses kept at pasture have greater freedom and more opportunity for social interaction, and the prevalence of stereotypic behaviours is reduced in pastured horses compared with horses that are stabled (Pell & McGreevy 1999). Compared to horses housed and grown in confined or smaller areas the opportunity for exercise in young pastured horses could prove favourable to future athletic ability (Firth *et al.* 1999). The total distance covered is related to paddock size. Most NZ paddock sizes are around 10 acres (4 ha), so the degree of exercise of foals is still much less than that of feral foals (Hampson *et al.* 2010). Rogers *et al.* (2008), found that TB foals subjected to conditioning exercise did not have any adverse effect on their subsequent racing careers at age 2 and 3 years. The lack of negative effects and the indications of some positive effects of early conditioning exercise may be an advantage for pastured horses further assisting in the development of healthy athletic individuals.

Therefore, the production, supply and management of quality pasture for grazing bloodstock is important to any breeding operation. The significant investment that a stud farm has in highly productive pasture should be purposefully utilised, with consideration of the seasonal supply of pasture, the stocking capacity of the land and sound pasture management practices which result in efficient utilisation of the land and forage grown on it.

In NZ, studies on the quality of equine pasture in recent times are scarce, with the last documented survey of equine pasture carried out by Goold *et al.* (1988), on two Thoroughbred breeding farms in the Waikato; and Wallace (1977), on three Thoroughbred farms in the Waikato. The pasture challenges identified in these studies related to poor pasture utilisation during the growing season and the uneven nutrient transference due to faecal avoidance and the subsequent development of roughs (faecal contamination), and lawns (overgrazed). Horses are highly selective grazers and will damage the healthy sward by overgrazing desirable pasture plants allowing weeds and unpalatable plants to become dominant in the swards. As horses spend much of their time walking around seeking palatable forage they damage plants by trampling more than sheep and cattle. These problems are particularly exacerbated by wet, ‘puggy’ paddocks. Differences in nutrient composition was found between horse farms and sheep/dairy farms (even given similar soil/land type), and was related to differing management practices (Goold 1988). There is a clear requirement for further and more comprehensive investigation of pasture quality and management practices found on commercial Thoroughbred and Standardbred breeding farms in NZ.

The quantification of the quality and composition of the pasture during each herbage growth cycle will allow for the accurate and optimal use of both pastures and supplements. Application of this knowledge will permit formulation of balanced diets for horses to potentially improve growth and minimising wastage due to DODs.

The aim of this project was to describe the seasonal patterns of pasture quality (chemical and botanical composition), during one year (2009), on 26 commercial Thoroughbred and Standardbred farms in five regions of New Zealand. The data collected will provide baseline data on the quality of equine pasture during seasonally distinct periods in different regions of NZ.

3.1 Materials and Methods

3.1.1 Experimental design-the selection of properties

The sampling frame consisted of commercial Thoroughbred and Standardbred breeding farms within New Zealand. Commercial Thoroughbred breeding farms were defined as farms with >10 yearlings sent to the premier, select or festival yearling sales in 2008 (www.nzb.co.nz) and/or standing ≥1 stallion that was covering ≥30 mares (register of Thoroughbred Stallions of New Zealand 2006). Commercial Standardbred breeding farms were defined as either standing >2 stallions, or operating as a stallion station serving ≥30 broodmares (www.hrnz.co.nz). This definition provided a sampling frame of 49 Thoroughbred breeding farms and 11 Standardbred breeding farms.

After stratification by region, a sample of Standardbred (n = 7) and Thoroughbred (n = 25) farms of the 60 potential breeding farms were identified and contacted. The restriction of the sample was based on logistics of sampling time and the time required for sample preparation and analysis. Two months prior to the start of the study an invitation letter was sent to the 32 equine breeding farms across New Zealand. The contact details for the Thoroughbred breeding farms were obtained from the NZ Thoroughbred Stallion Register (2006) and contact details for the Standardbred breeding farms were sourced from Harness Racing NZ.

The invitation letters were followed up 3 weeks later up by a phone call explaining the study in greater detail and seeking confirmation from each breeding farm of enrolment in the study.

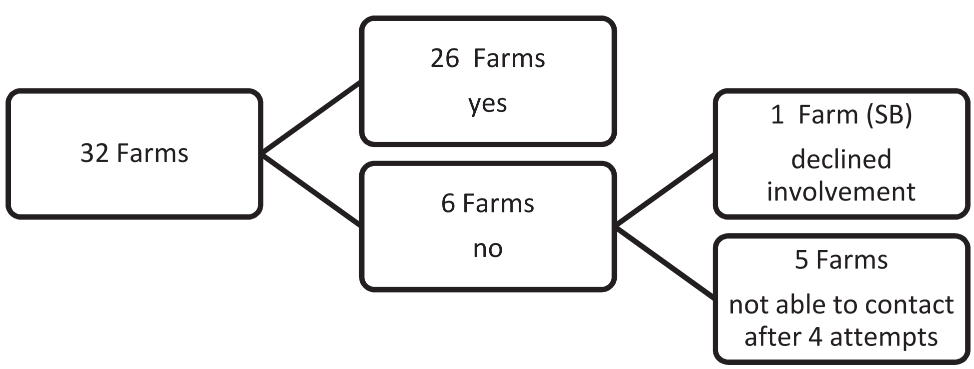


Figure 3.1: Process of determining breeding farms in study.

Of the 26 properties recruited, 4 were Standardbred breeding farms and 22 were Thoroughbred breeding farms (Table 3.1). Most were located in the Waikato (46%), South

Auckland (16%), Manawatu (15%), Canterbury (12%), Southland (8%), and the least in Wairarapa (8%).

Table 3.1: Regional distribution of commercial (as defined in materials and methods) Thoroughbred and Standardbred breeding farms in NZ. Numbers in brackets identify those properties in area which are part of the study.

	Thoroughbred Studs	Standardbred Studs
Auckland	6 (4)	1(0)
Waikato	33 (12)	1(0)
Manawatu	5 (4)	-
Wairarapa	1 (1)	-
Canterbury	3(1)	7(2)
Otago/Southland	1(0)	2(2)

The sampling periods (Table 3.2), were: summer (February), autumn (April), winter (late June/early July), early spring (late August/early September), and late spring (November).

Table 3.2: Sampling periods for pasture collection

Sampling Period	Dates (2009)
Summer	09/02 – 19/02
Autumn	13/04 – 23/04
Winter	22/06 – 02/07
Early Spring	24/08 – 04/09
Late Spring	09/11 –18/11

At the end of each of the sampling periods the breeding farms taking part in the pasture study were sent a copy of their own results (chemical and botanical composition), whilst maintaining confidentiality between each breeding farm.

3.1.2 Pasture sampling

Discussion with the stud master identified the larger paddocks on the farm where broodmares and young stock were grazed for long periods. Paddocks scheduled for pasture renewal during the study period were excluded. Three paddocks from each farm were chosen by reviewing a farm map and choosing areas from different parts of the farm. For example, one breeding farm was segregated into a weanling area, a broodmare unit and a yearling area. One paddock from each of these areas was sampled.

On each farm, three paddocks were sampled from during each seasonal period. The time of day of sampling for each particular farm was kept constant across sampling periods to reduce any potential effect of time of day being confounded with season.

At the initial collection (February – summer) within each paddock, GPS coordinates were used to identify the start and finish of the sampling transect so that during each return visit the pasture could be collected from the same transect. Each starting transect point was taken from 15 metres inside the paddock, beyond those areas on the perimeter that become bare in summer and muddy in winter from constant trampling. At each site pasture samples were taken from the areas which the horses prefer to graze, not from rough and rank, 'latrine' areas where the horses don't graze, (Goold 1988).

Pasture samples were collected at a height which related to the pasture cover at the particular time, i.e., in longer pasture the top two-thirds of the sward was sampled leaving behind the stalky base of the sward, whereas in shorter pasture samples the entire height of the sward was collected down to the base in an effort to simulate the actual grazing behaviour and nutrient intake by the horses in any given paddock at the time of sampling. In longer swards horses will only consume the top two-thirds and leave the stalky base behind. Conversely on short pasture, it is often grazed to ground level and sometimes the root system of the plant is consumed.

Samples were taken at approximately 5-10 m intervals along the transect line. Each clip was taken by using hand-shears and resulted in approximately a handful of pasture (10-20 g of pasture). At least 30 clips per paddock were taken for each sample, culminating in a sample of approximately 0.5 kg of pasture fresh weight (FW), collected from each paddock. During each sampling period a photograph of every paddock was taken to assist with the interpretation of pasture quality.

Following collection, the sample from each paddock was mixed well in a large 20 L bucket and separated into two sub-samples (approximately 100 g fresh matter each), for chemical composition and botanical composition, with the remaining pasture frozen (-20 °C), as a retention sample. All samples were rapidly cooled to 5°C to preserve sample integrity. Samples for chemical composition were kept at 5°C until being dried within 48 hours of collection in preparation for analysis.

Fresh pasture samples for botanical composition were categorised into ryegrass, other grasses, (excluding ryegrass), legumes, weeds and dead matter. Each component was separately weighed, (Mettler Toledo top-pan balance), oven-dried at 110°C for 18 hours and then re-weighed to determine the contribution by weight of botanical composition, which is expressed as a % DM for each sample.

3.1.3 Laboratory Analyses

The chemical composition of the pasture samples were predicted using Near-Infrared-Spectroscopy (NIRS) analysis (Corson *et al.* 1999, Roberts *et al.* 2004, Sirois 2001), at the FeedTech laboratory at AgResearch, Palmerston North, NZ. Analyses included metabolisable energy (ME), crude protein (CP), soluble starch and sugars (SSS), mineral (ASH), lipid, fibre contents (ADF, NDF) and organic matter digestibility (OMD).

In preparation for NIRS, pasture samples were dried at 65°C to constant weight then finely ground using a grinding mill (IKA Werke), fitted with a 1 mm sieve. Samples were then stored in specialized NIRS vials with the remainder of the dried ground sample labelled and stored in an airtight container for future analysis.

Samples were scanned using a Bruker MPA NIR spectrophotometer (Ettlingen, Germany), and the resulting NIR spectra analyzed using Optic user software (OPUS) version 5.0.

The NIRS calibrations used by FeedTECH were developed using NIRS to scan finely ground dried pasture samples in the range of 400 to 2500 nm. The NIRS calibration data are based on a large data set of over 14000 pasture samples over a considerable period of time (Table 3.3).

Table 3.3: Summary of NIRS calibration details

Component	Number of Standards	Regression coefficients (%)	Calculated NIR error (%) ±
DM	392	86.56	0.83
Ash	233	83.75	8.65
ADF	482	91.66	6.14
NDF	254	92.54	5.99
CP	291	96.77	7.3
Lipid	230	93.72	7.69
SSS	203	87.53	16.5
OMD	398	98.2	1.72
ME	387	99.09	1.09

NOTE: These calibration data were provided from FeedTech, AgReseach.

The calibration data were provided by FeedTech, AgResearch. Pasture samples had previously been analyzed for dry matter (DM), mineral (ash), crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF), soluble starch and sugars (SSS) and lipid by wet chemistry methods (Corson *et al.* 1999). The organic matter digestibility (OMD), and metabolisable energy (ME), values used for calibration were determined from animal feeding trials. The calibrations were based on principal component analysis using the most appropriate mathematical treatment for each component, and are summarised in Table 3.3.

3.1.4 Statistical analysis

Data were initially examined using histograms and plots to identify outliers and transcription errors. The botanical and chemical composition variables were examined using a general linear model, with season and region as fixed effects, and stud farm as a random effect. Data were examined using PASW Statistics v18, (SPSS Inc Chicago IL, USA), with a significance level of $p<0.05$. Bonferroni post hoc test was applied to multiple comparisons.

3.2 Results

Over the reported total TB and SB population in NZ, the total number of broodmares and foals/weanlings that are found within the breeding farms participating in the pasture study is shown in Table 3.4. The data is derived from reports by the Thoroughbred industry (2007-2008 season), and the Standardbred industry (2006-2007 season).

Table 3.4. Total number of registered Thoroughbred and Standardbred mares and foals during the 2006-2007 season (SB), and 2007-2008 season (TB). (Data in brackets represent the estimation of the percentage of these that were managed by the selected breeding farms at the time of the survey).

	Mares	Foals
Thoroughbred 2007-2008 season	4210 (52%)	2519 (61%)
Standardbred 2006-2007 season	1550 (38%)	1130 (41%)

3.2.1 Climatic conditions

3.2.1.1 Temperature

During the period of pasture collection, 9 February 2009 through to 18 November 2009, the average regional air temperature was slightly lower in most seasons (particularly during winter, 8-22% lower; and late spring 3-8% lower), than the 30-year average (NIWA climate database, Figure 3.2).

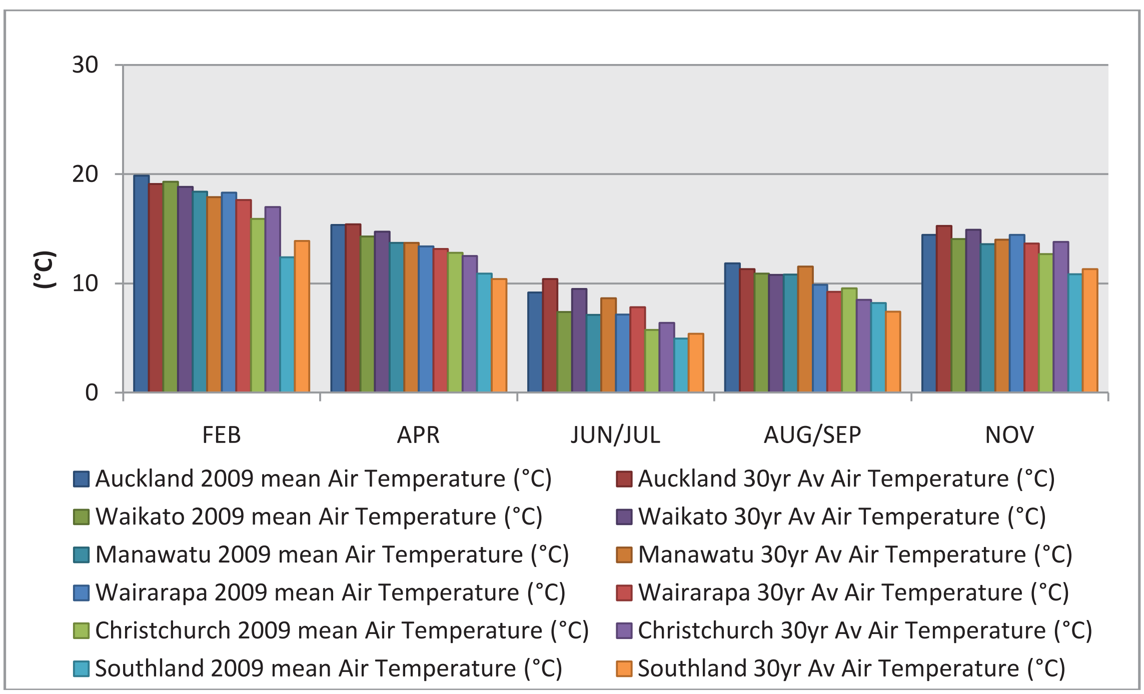


Figure 3.2: Average regional monthly air temperature during 2009 versus the 30-year averages for air temperature, (°C). Each regional 30-year comparison is stacked next to its 2009 value for each region in each seasonal period.

3.2.1.2 Rainfall

Total rainfall for 2009 was similar to the 30 year average in the Auckland, Waikato, Wairarapa, Canterbury and Southland regions. During 2009 the Manawatu region recorded a higher rainfall (20% or 1114.4 mm versus 895.5 mm), than the 30-year average. Southland, Auckland and Waikato had slightly less rainfall than the 30-year average (16%, 10% and 7%, respectively). Wairarapa and Christchurch annual rainfall values were similar to the 30-year average, see Figure 3.3.

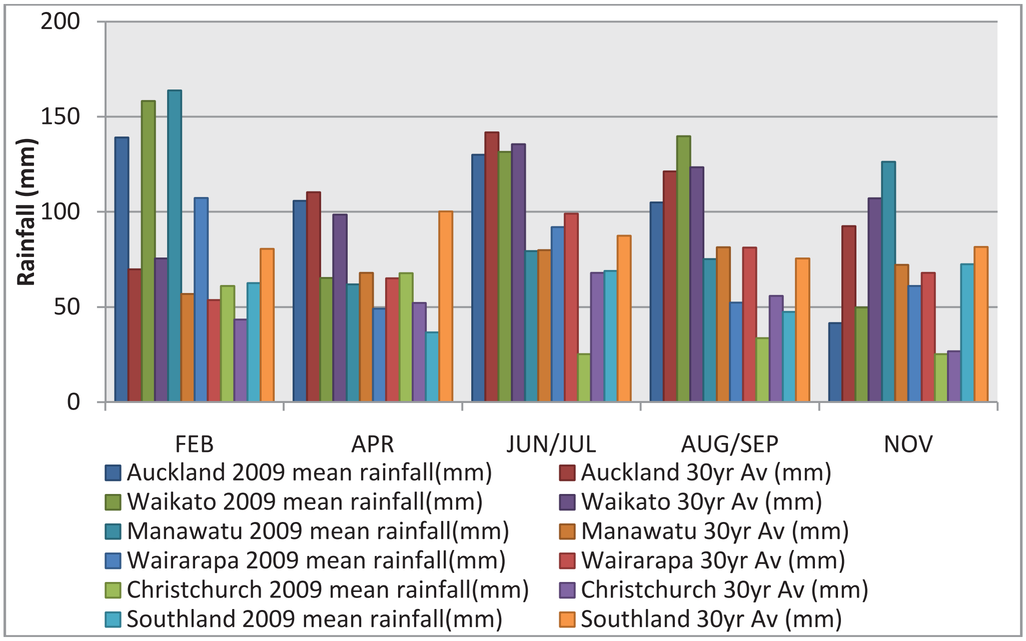


Figure 3.3: Regional seasonal average rainfall for 2009 versus the 30-year average data.

The official NIWA rainfall data for 2009 (Figure 3.4), revealed a number of regional and seasonal differences to the 30-year averages, namely

- Rainfall was above average in February in most regions (42 –187% higher), apart from in the Southland region (22% lower).
- April rainfall was generally below average (4 –63% below 30 year-average), particularly for Wairarapa (25%), Waikato (25%) and Southland (63%) which were less than the 30-year-average. Christchurch was the only region to have a higher rainfall than the 30-year average in April (31% higher).
- Winter rainfall was similar to the 30-year average for all regions except for Christchurch which was well below the data for the 30-year average (63%).
- Rainfall in early spring was above average for Waikato(12%), and below average for Auckland (13%), Wairarapa (36%), Christchurch(39%) and Southland (37%).

- Late spring rainfall was below average for Auckland (55%) and Waikato (53%), and above average for Manawatu (43%), and around normal for Wairarapa, Christchurch and Southland.

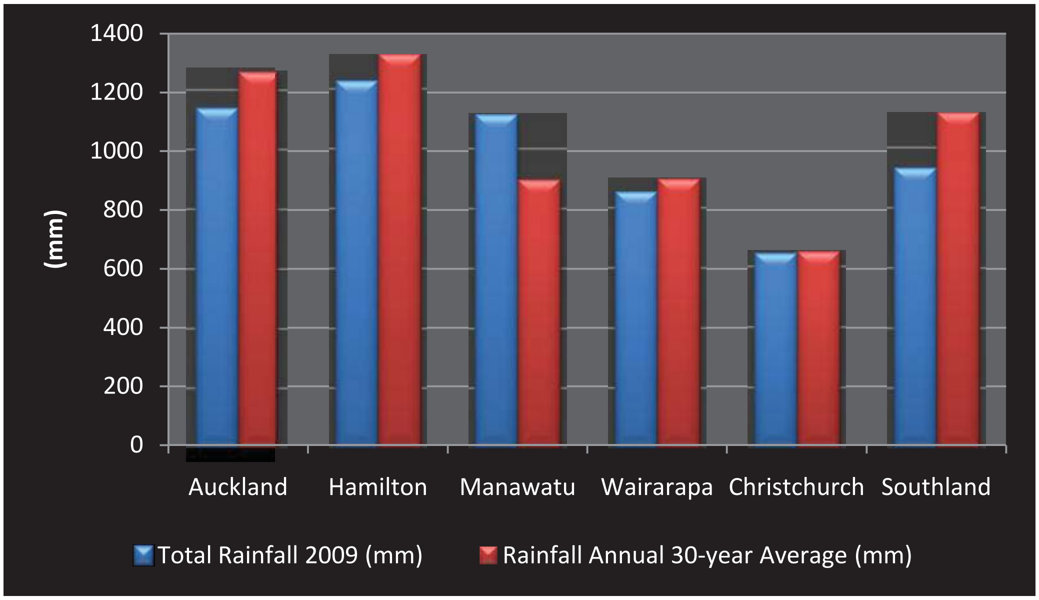


Figure 3.4: Regional annual rainfall for 2009 versus 30-year average rainfall data.

3.3 Botanical Composition.

Botanical composition data are presented as percentages based on total dry matter (% DM). Over the duration of the study period there were significant seasonal changes in the botanical composition of pasture (Table 3.5).

Table 3.5: Seasonal botanical composition of equine pasture in New Zealand, expressed as mean (± SEM) % of total DM.

Mean±SEM	***Summer***	***Autumn***	***Winter***	***Spring1***	***Spring2***
Ryegrass	42.37±2.28[a]	63.28±2.02[bde]	79.95±2.25[c]	69.53±2.35[bd]	57.43±2.56[be]
Grass	18.66±1.83[abde]	15.94±1.77[abcde]	10.43±1.61[bd]	12.17±1.78[abcd]	20.56±2.18[abe]
Clover	12.82±1.51[abe]	10.33±1.16[bde]	2.55±0.43[c]	7.99±0.95[bde]	10.19±1.11[abde]
Weed	6.38±0.95[abce]	6.32±0.79[abce]	3.38±0.58[bc]	9.70±1.20[de]	8.90±1.26[abde]
Dead Matter	19.77±1.81[a]	4.13±0.73[bce]	3.70±1.19[bcde]	0.59±0.41[cde]	2.92±0.80[bcde]

Within a row, values with different superscripts are significantly different, P < 0.05. SEM = standard error of the mean.

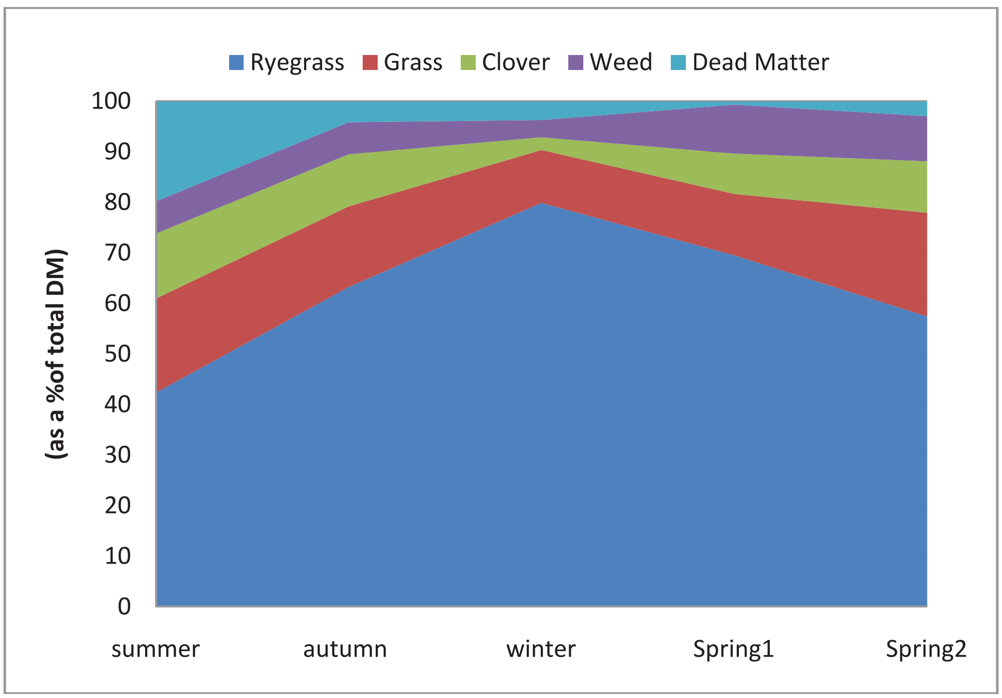


Figure 3.5: Seasonal Changes in Pasture Botanical Composition (% of total DM)

Consideration of each sward category individually shows that the percentage contribution of ryegrass in the total pasture DM was least during summer, 42.37% DM (±2.28) and greatest during winter, 79.95% DM (±2.25), (P=<0.01), (Table 3.1, Figure 3.5). The contribution of ryegrass to the overall botanical composition did not differ during autumn 63.28% DM (±2.02), and the two spring periods 69.53% DM (±2.35); 57.43% DM (±2.56), respectively. The majority of the variance in the model was attributed to both breeding farm (37%), and season (38%).

The contribution of other grasses to the overall botanical composition did not differ between summer, autumn, early or late spring, however, the percentage of grasses in the sward decreased during winter. The contribution of other grasses to the botanical composition was at its lowest value during winter. The variation in the other grasses was largely a breeding farm effect (53%).

The contribution of legumes to the overall botanical composition was significantly different during the winter period to all the other seasonal sampling periods (P=<0.01). Legumes contributed least to botanical composition of the sward during the winter period. During the autumn, summer, early spring and late spring periods the contribution of legume to the botanical composition did not differ. Individual stud accounted for a modest variation in legumes (39%), with some variation coming from seasonal effects (15%). However, most of the variation of legume contribution to pasture composition was due to the interaction of the breeding farm and season, with legume contribution being at its lowest during winter.

Weed contribution to the botanical composition was at its highest in early spring and at its lowest during winter. Individual stud (50%), accounted for most of the variation in the percentage of weed in the sward as opposed to seasonal effects.

The highest level of dead matter present in the sward was in summer, whereas early spring 0.59% DM (±0.41) had the least amount of dead matter present. The variation in dead matter content was accounted for mainly by the seasonal effect (49%), with some season*stud effect also present.

3.3.1 Botanical composition - regional analysis

Regional analysis of the seasonal changes in the botanical composition of the sward showed similar trends for most areas with some deviation from the trends observed during specific seasonal periods in some regions. As shown in Figure 3.6 the pattern of ryegrass composition of pasture across the seasons showed the same rise in % of total DM from summer to winter for all regions, except Southland, which ryegrass composition dropped very slightly before rising again in early spring. All other regions had the highest level of ryegrass in the sward during winter, with the percentage of the sward in ryegrass almost falling to summer levels by late spring. Manawatu showed a drop in early spring, followed by slight rise in late spring. South Auckland showed the greatest fall in ryegrass composition between winter and late spring.

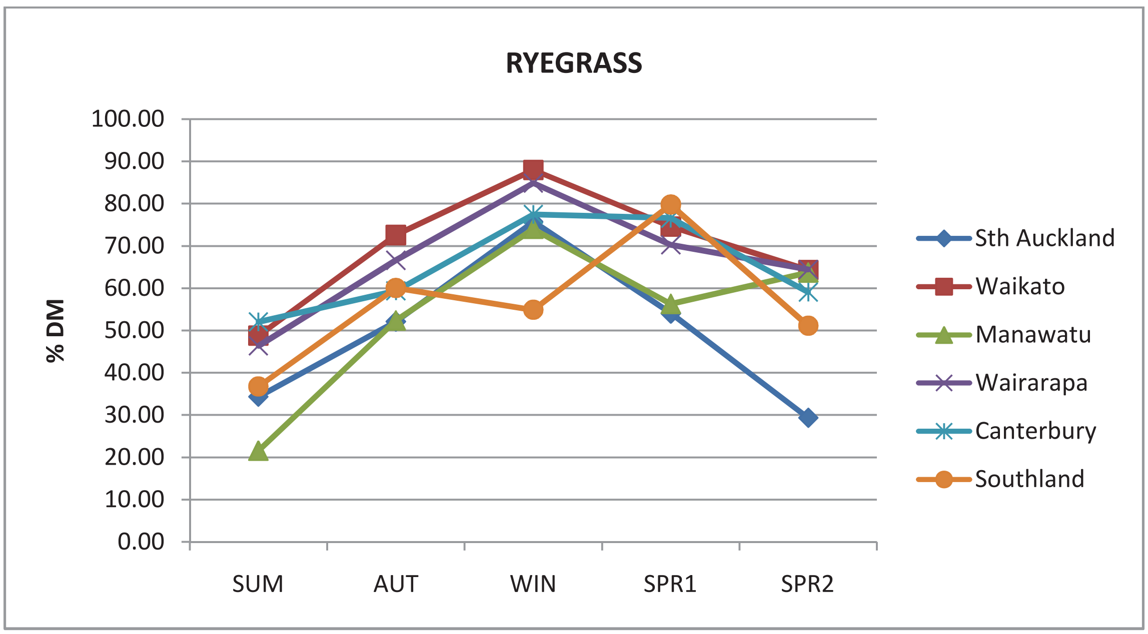


Figure 3.6: Seasonal variation in ryegrass as a % of DM of seasonal composition during the 2008-2009 breeding season.

The proportion of other grasses in the sward was much lower than for ryegrasses and generally showed the opposite trend to ryegrass contribution to sward composition (Figure 3.7). The contribution of other grasses to the sward fell slightly to winter with the exception of Southland which continued to fall (as a % of total DM) into early spring. There was a rise in the % going into early spring for South Auckland, Waikato, and Wairarapa; while Manawatu and Canterbury remained fairly static over this period. The grasses continued to rise to late spring (as a contribution to % total DM) for South Auckland, Waikato and Canterbury, while Manawatu and Wairarapa fell slightly. Southland saw a large increase in the % composition of grasses in the sward (from around 7% total DM in early spring to 35% of total DM in late spring).

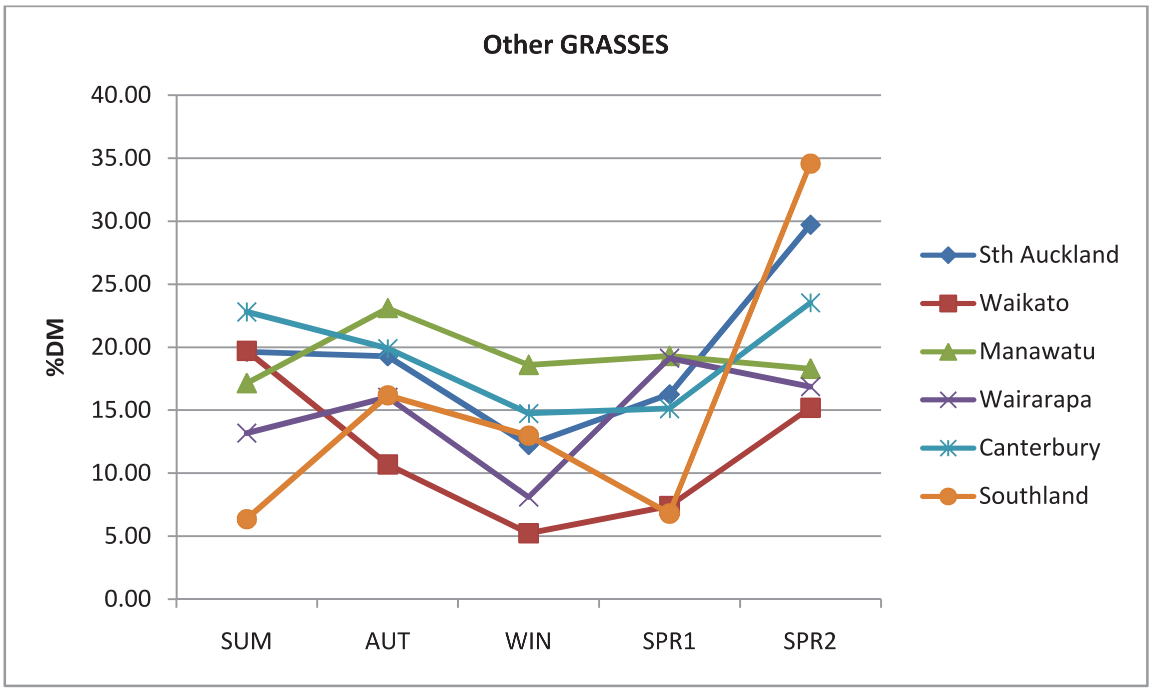


Figure 3.7: Seasonal variation in other grasses as a % of DM of seasonal composition during the 2008-2009 breeding season.

The contribution of legumes to the sward during the summer period was variable across all regions, ranging from approximately 25% of the total DM (Southland), down to approximately 7% of total DM (Waikato), (Figure 3.8). All regions showed a decrease in % legumes in autumn, followed by a marked fall into winter, when all regions were in the range of 1-5% of total DM. All regions showed an increase in legume in the sward into early spring, which continued through late spring, except for Manawatu which fell to almost winter levels (approximately 5%). The areas with irrigation (Southland, Canterbury and Wairarapa) and the Manawatu which had a higher rainfall level in summer all had higher levels of legume during the warmer months

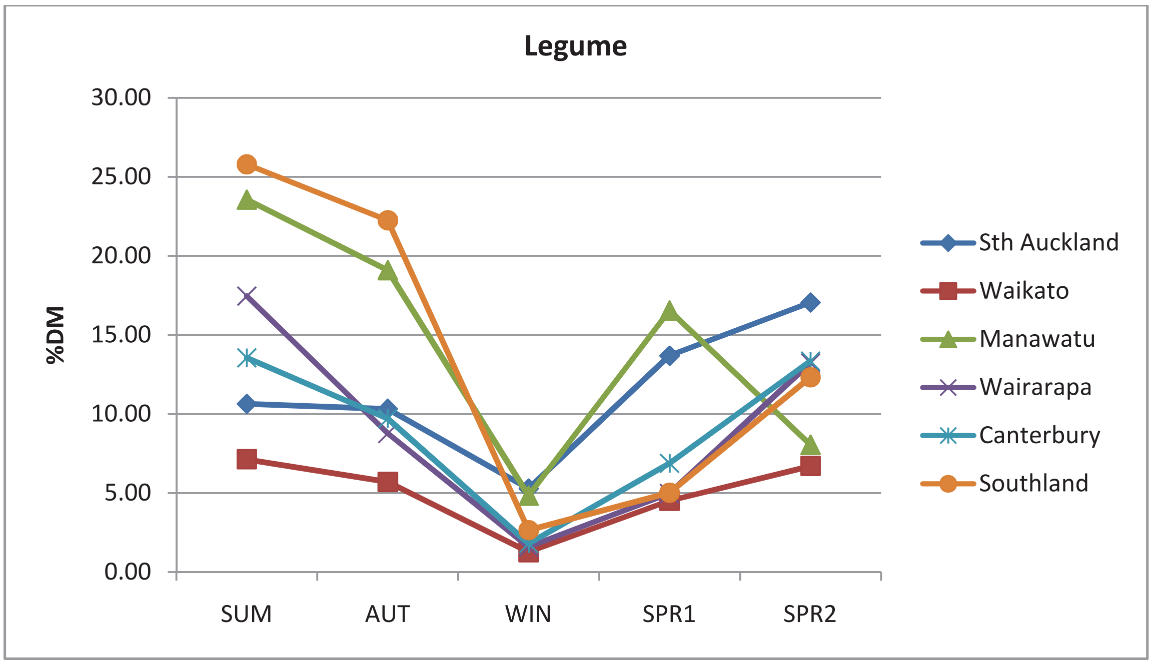


Figure 3.8: Seasonal variation in legume as a % of DM of seasonal composition during the 2008-2009 breeding season.

Weed levels in the sward generally showed a decline in winter for all regions, increasing with more favourable climatic factors for growth (Figure 3.9). While the Northern areas showed large seasonal differences in the % contribution to the total sward, the difference were smaller for Manawatu, Wairarapa and Canterbury – but with a similar trend. Southland was different to all other regions with the % of weeds in the total sward remaining fairly static and not rising above 2% across all seasons.

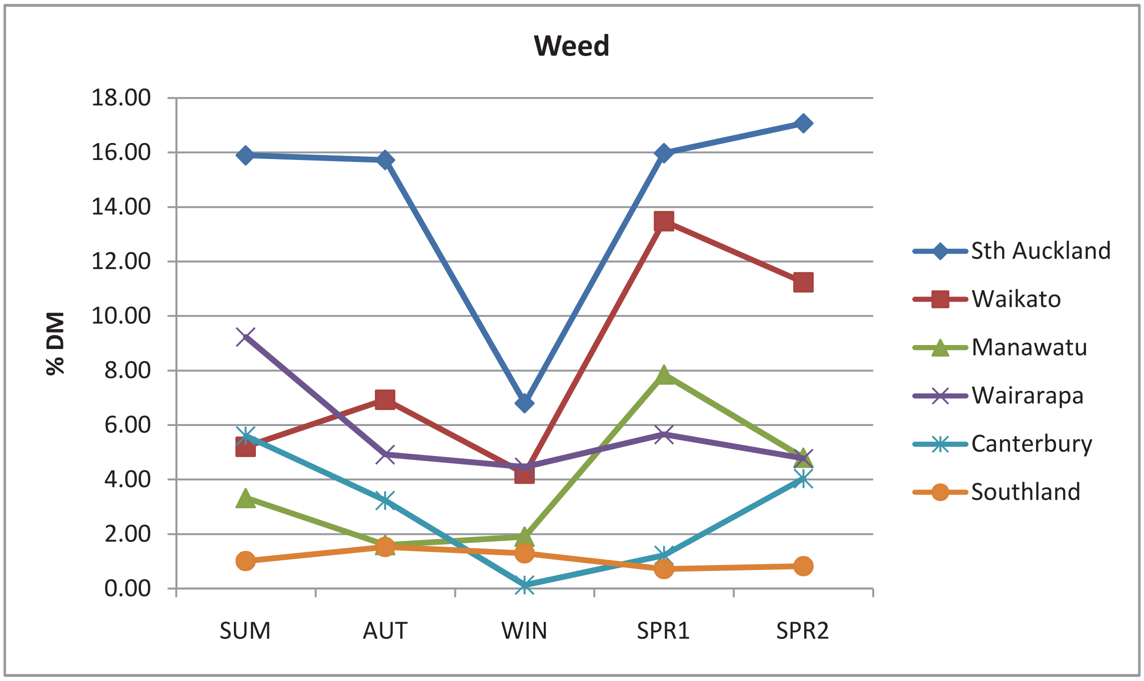


Figure 3.9: Seasonal variation in weed as a % of DM of seasonal composition during the 2008-2009 breeding season.

The percentage of dead matter in the sward fell markedly from summer into autumn particularly for South Auckland, Waikato, Manawatu and Southland. The same degree of decrease was not evident for Wairarapa and Southland (Figure 3.10). The percentage of dead matter in the sward in Southland followed a different pattern to all other regions. While the percentage of dead matter in the sward decreased in all other regions going into winter and early spring, Southland had a large increase into winter (almost to summer levels), before falling in early spring. All regions had a similar level of dead matter in the sward during late spring from <1% of total DM to approximately 7% of total DM. The regions with irrigation (Canterbury and Wairarapa) had reduced levels of dead matter in the pasture during summer, however after autumn rainfall there was little difference in dead matter over all regions. While there was a regional effect on the botanical composition of the sward often individual stud accounted for the observed differences. These differences would have been as a result of different pasture utilisation levels between farms.

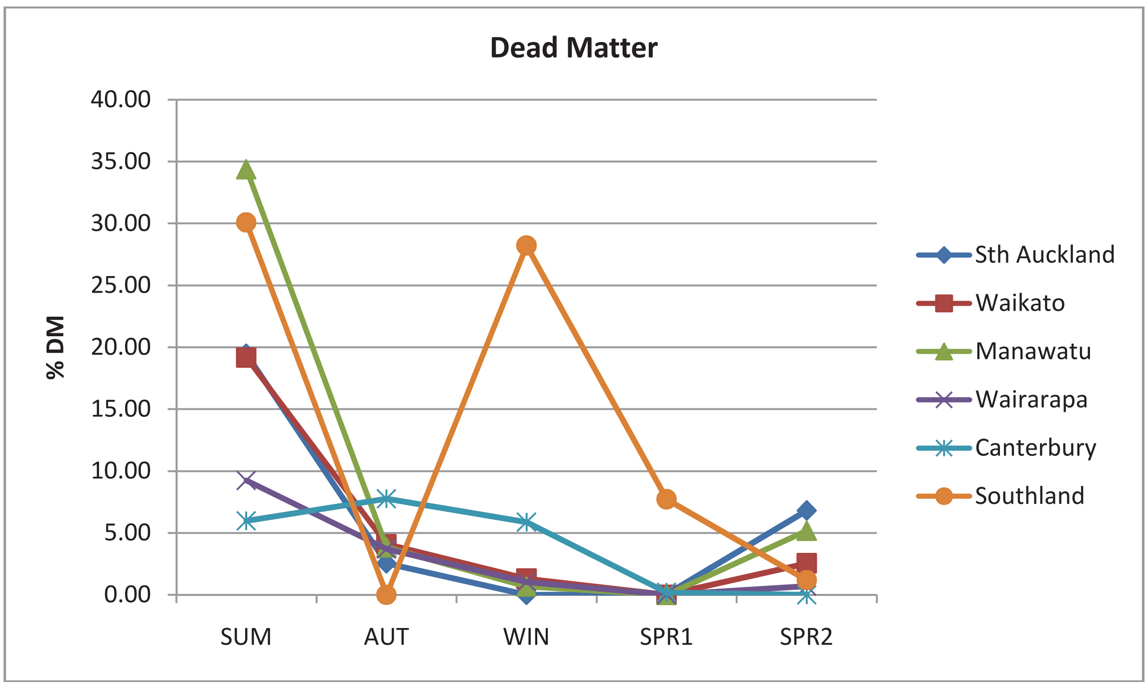


Figure 3.10: Seasonal variation in dead matter as a % of DM of seasonal composition during the 2008-2009 breeding seasons.

3.4 Chemical composition

The pasture samples were analysed by NIRS for crude protein (CP), mineral (ash), acid detergent fibre (ADF), neutral detergent fibre (NDF), lipid, soluble starch and sugars (Sol CHO), and organic matter digestibility (OMD), (which are expressed as a % of DM); and metabolisable energy, (ME MJ/kg DM). The seasonal variation of chemical composition of pasture is shown in Table 3.6.

Table 3.6: Seasonal variation of the chemical composition of equine pasture in New Zealand.

Mean ±SEM	*summer*	*autumn*	*winter*	*Spring1*	*Spring2*
ME	9.25±0.09^{a}	10.67±0.10^{b}	11.24±0.11^{c}	12.63±0.06^{d}	11.99±0.06^{e}
CP	18.61±0.44^{ae}	20.96±0.38^{be}	23.14±0.34^{c}	26.57±0.35^{d}	19.65±0.40^{abe}
Lipid	2.19±0.07^{a}	3.32±0.06^{bc}	3.49±0.07^{bc}	3.83±0.04^{d}	3.08±0.04^{e}
ADF	27.96±0.36^{a}	25.23±0.28^{be}	24.05±0.29^{c}	21.92±0.17^{d}	24.86±0.23^{be}
NDF	55.84±0.65^{a}	43.40±0.49^{bc}	43.18±0.66^{bc}	39.01±0.40^{d}	46.45±0.40^{e}
Ash	9.49±0.10^{ae}	10.63±0.11^{bc}	10.87±0.09^{bc}	11.43±0.12^{d}	9.38±0.13^{ae}
Soluble CHOs	5.09±0.26^{a}	10.48±0.27^{bcd}	10.93±0.29^{bcd}	11.02±0.36^{bcd}	12.32±0.30^{e}
OMD	63.46±0.80^{a}	74.86±0.67^{b}	76.80±0.77^{c}	86.40±0.47^{d}	80.30±0.40^{e}

NOTE: Within a row, averages with different superscripts are significantly different, $P < 0.05$.
SEM = standard error of the mean.

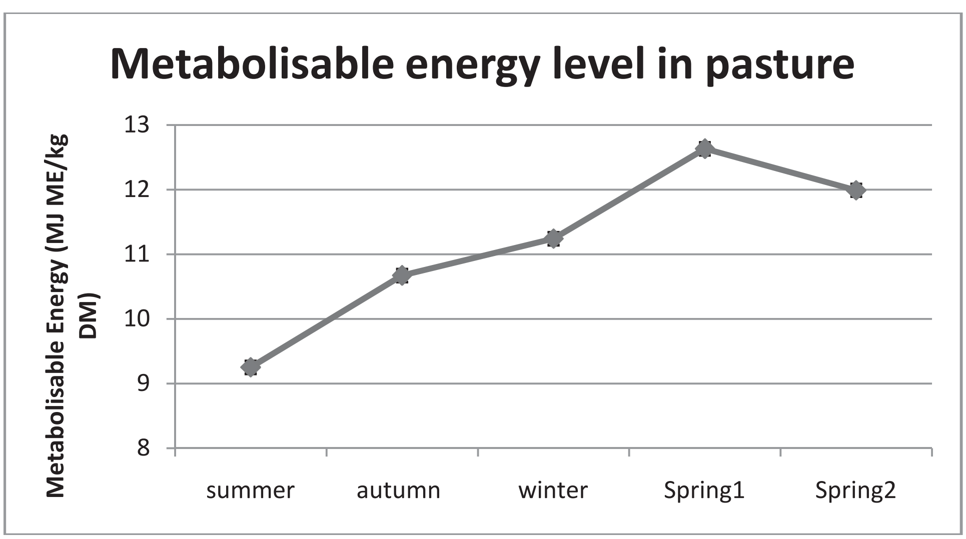


Figure 3.11: Metabolisable Energy 2008-2009 Breeding season.

Metabolisable Energy (ME) MJ/kg DM was significantly different between each seasonal period (Figure 3.11). It was at its lowest in summer, 9.3 MJ/kg DM, (±0.1) climbing to its highest point during the early spring period, 12.6 MJ/kg DM, (±0.06) before falling slightly during the late spring period, 12.0 MJ/Kg DM, (±0.06). The variation was attributed to seasonal changes in the pasture quality e.g., the increasing or decreasing levels of dead matter.

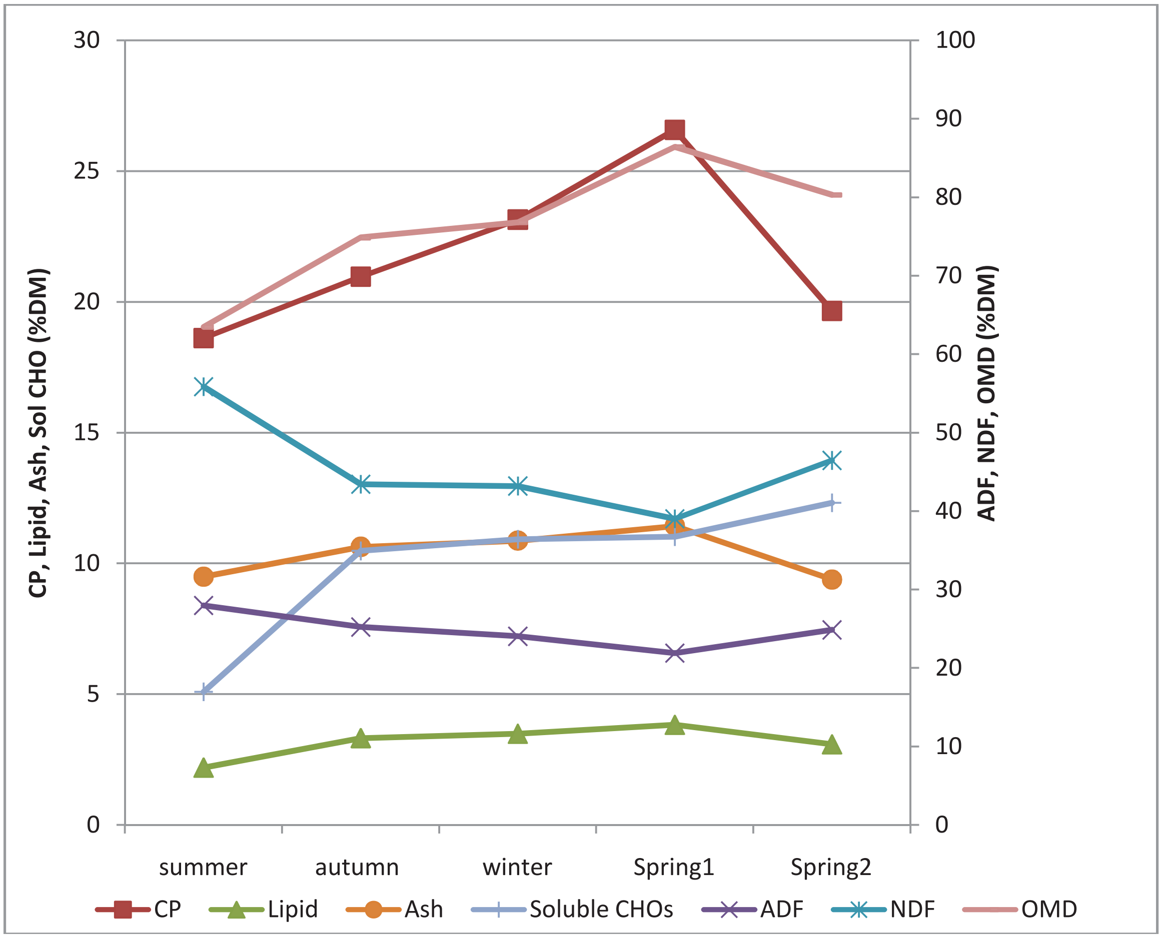


Figure 3.12: Chemical composition of pasture during 2008-2009 breeding season.

Crude protein (%CP DM) also followed a seasonal pattern and was at its lowest during the summer period 18.6%, (±0.4) but was not significantly different to the level of CP observed during the late spring period 19.7% (±0.4). Autumn was 21.0% CP (±0.4), while significantly different to summer, winter and early spring, it was not significantly different to late spring where CP values had fallen again. Both winter 23.1% CP, (±0.3) and early spring 26.6%, (±0.4) were significantly different to each other and all other seasonal periods. CP was at its highest during early spring. Most of the variation was attributed to seasonal changes in pasture quality.

Fibre levels (ADF & NDF, as a % of DM) follow a seasonal trend, with summer significantly higher for both ADF and NDF compared to all other seasonal periods. For ADF winter and early spring were significantly different to each other and the other seasonal periods, whereas for NDF the levels during winter were not significantly different to autumn, but different to all other seasonal periods. NDF was significantly different between each of the spring periods and all other seasonal periods. Fibre levels were at their lowest during early spring. The variation is explained by seasonal effects, with greater variation for season observed for NDF levels.

Soluble carbohydrate, (%DM) levels in the pasture were at low levels in summer 5.1%, (±0.3); before climbing to a highpoint in late spring 12.3%, (±0.3). Summer was significantly different to all other seasons, differing markedly by approximately half the concentration found during the other seasonal periods. Autumn soluble carbohydrate was 10.5%, (±0.3); winter 10.9%, (±0.3); and early spring 11.0%, (±0.4) which were not significantly different to each other, but were different to summer and late spring. Late spring is significantly different to all other seasons. The variation in soluble carbohydrate is mainly attributed to seasonal effects.

Ash (minerals), follow a seasonal pattern, with summer 9.5% (±0.1) and late spring 9.4% (±0.1), significantly different to all other seasonal periods, but not to each other. Mineral levels in pasture were low during summer and began to rise to their highest point in early spring, 11.4% (±0.1), however by late spring they have fallen just below summer levels. Autumn 10.6% (±0.1), and winter 10.9% (±0.1), were not significantly different to each other, but all other seasonal periods. Early spring, when mineral content is at its highest was significantly different to all other seasonal periods. Seasonal differences account for much of the variation, with some individual stud effect and stud*season effect.

Lipids make up a relatively small part of the overall pasture nutritional components. The levels found in pasture were representative of a seasonal pattern. Summer, early and late spring, were significantly different to each other and all other seasonal periods. Lipids were at their lowest in summer and their highest in early spring. Autumn and winter were significantly different to the other seasonal periods, but not different to each other. Most of the variation is attributed to seasonal changes in pasture quality.

Organic matter digestibility (OMD) is a measure of the digestibility of the pasture and has been calculated from models based on ruminants, however, for the purposes of comparing the values and the contribution that OMD has to pasture quality the results are presented here. OMD shows a seasonal trend with digestibility at its lowest during the summer period,63.5% (±0.8) before climbing to its highest point in early spring 86.4% (±0.5), then dropping back slightly in late spring 80.3%, (±0.4). The OMD level of pasture for all seasons is significantly different for every seasonal period. Most of the variation is due to seasonal effects, however there is some variation due to a stud*season effect.

3.4.1 Chemical composition – regional analysis

Regional analysis of the data showed similarities between some regions, while also revealing those which appeared to show a different pattern of composition.

Metabolisable energy levels showed a general increase post summer to the highest level during early spring before slightly falling during late spring for all regions except Southland. Southland levels fell considerably into winter before rising to the highest levels in late spring (Figure 3.13)

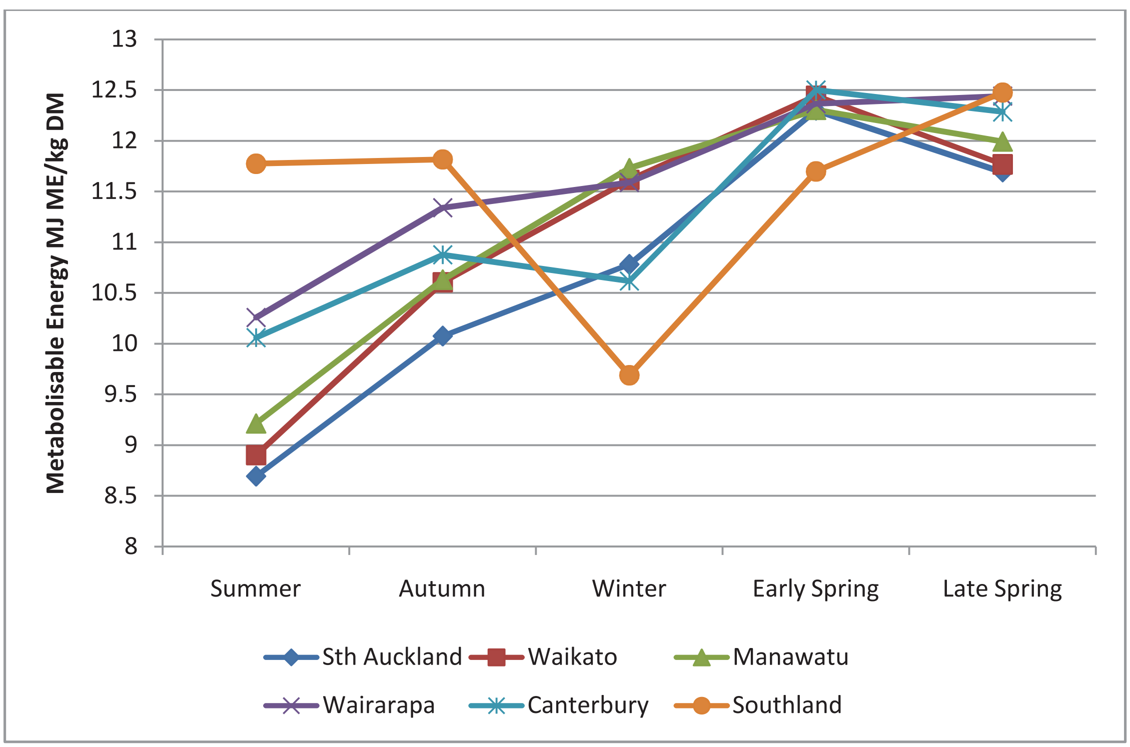


Figure 3.13: Seasonal variation in metabolisable energy (MJ ME/kg DM) for stud farms located in the six different regions during the 2008-2009 breeding seasons.

For all regions the crude protein levels were generally lowest in summer, rising to their highest levels in early spring, before falling slightly into late spring (Figures 3.14 -3.19).

Soluble carbohydrate levels generally rose from the lowest point in summer to higher values during autumn, winter and early spring for all regions. During late spring South Auckland and Waikato regions observed a decline in soluble carbohydrate levels, while levels continued to rise in Manawatu, Wairarapa, Canterbury and Southland.

Fibre levels (ADF and NDF) levels fell from the highest level in summer to the lowest in early spring before slightly rising into late spring. Southland was different to all other regions as it showed a rise in fibre levels in winter before falling during early and late spring.

Mineral levels were fairly static across the seasons, at approximately 10% DM for all regions. The contribution of lipid to the composition of the pasture was also fairly even across the year for all regions, (< 5%DM).

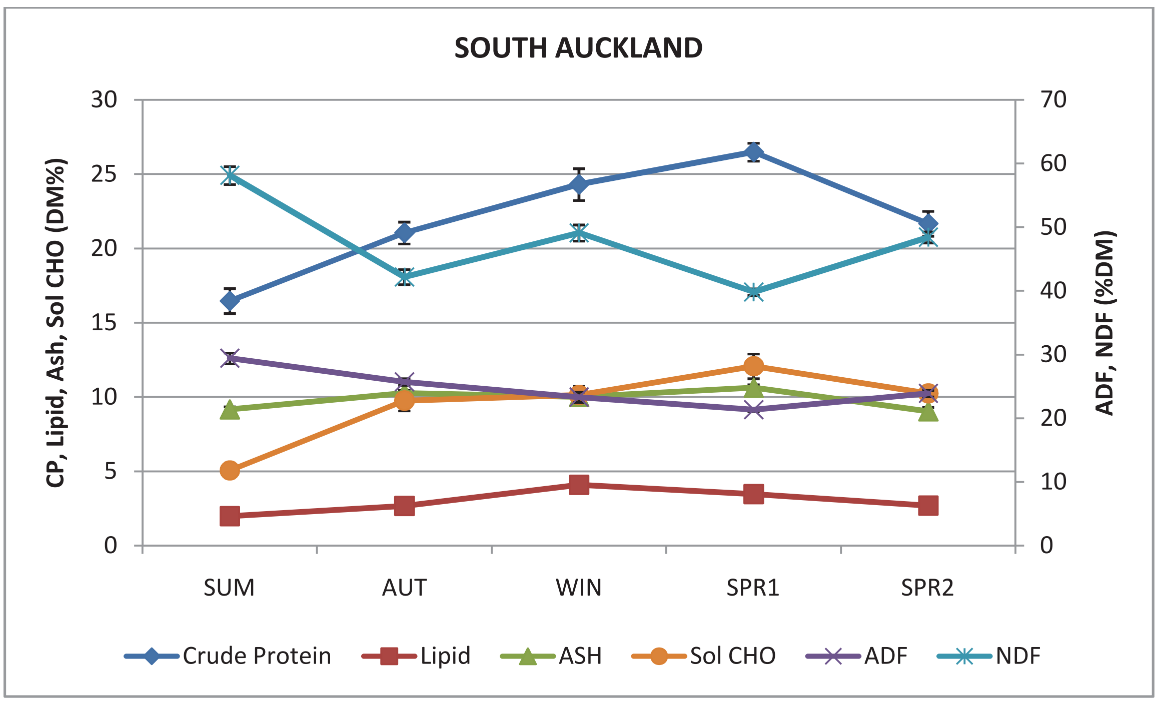


Figure 3.14: Seasonal variation in chemical composition for stud farms in the South Auckland region during the 2008-2009 breeding seasons.

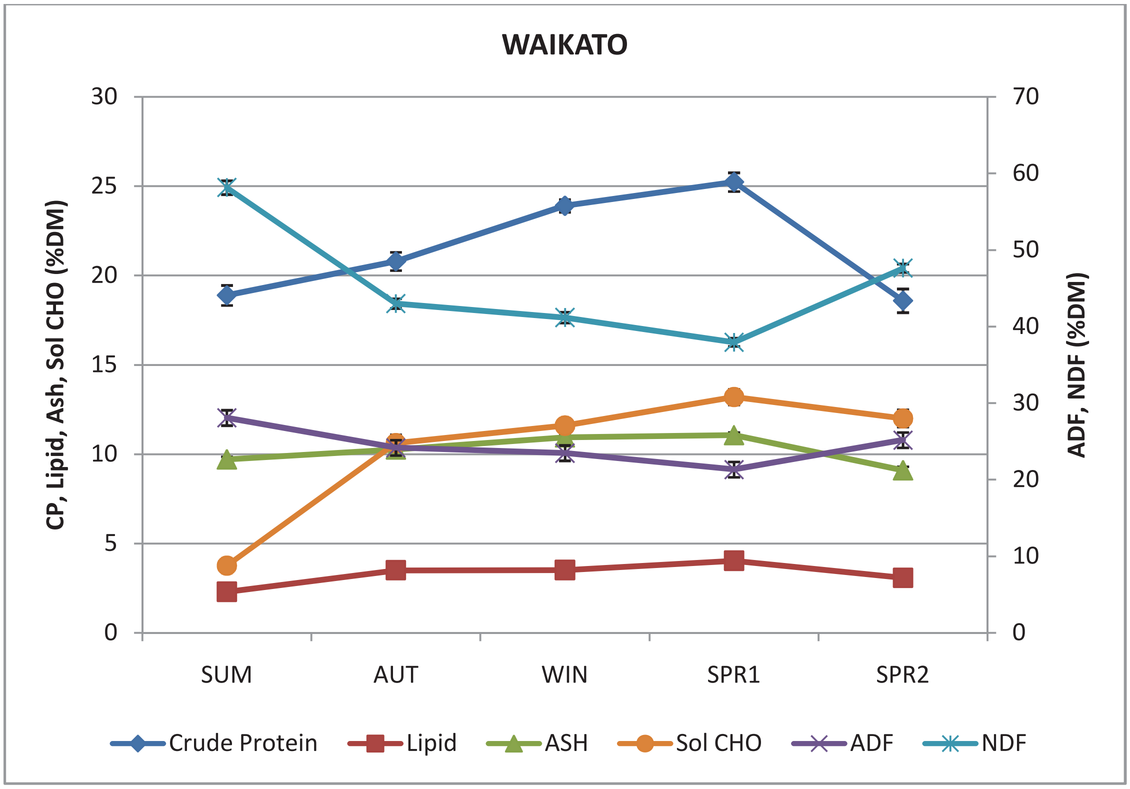


Figure 3.15: Seasonal variation in chemical composition for stud farms in the Waikato Auckland region during the 2008-2009 breeding seasons.

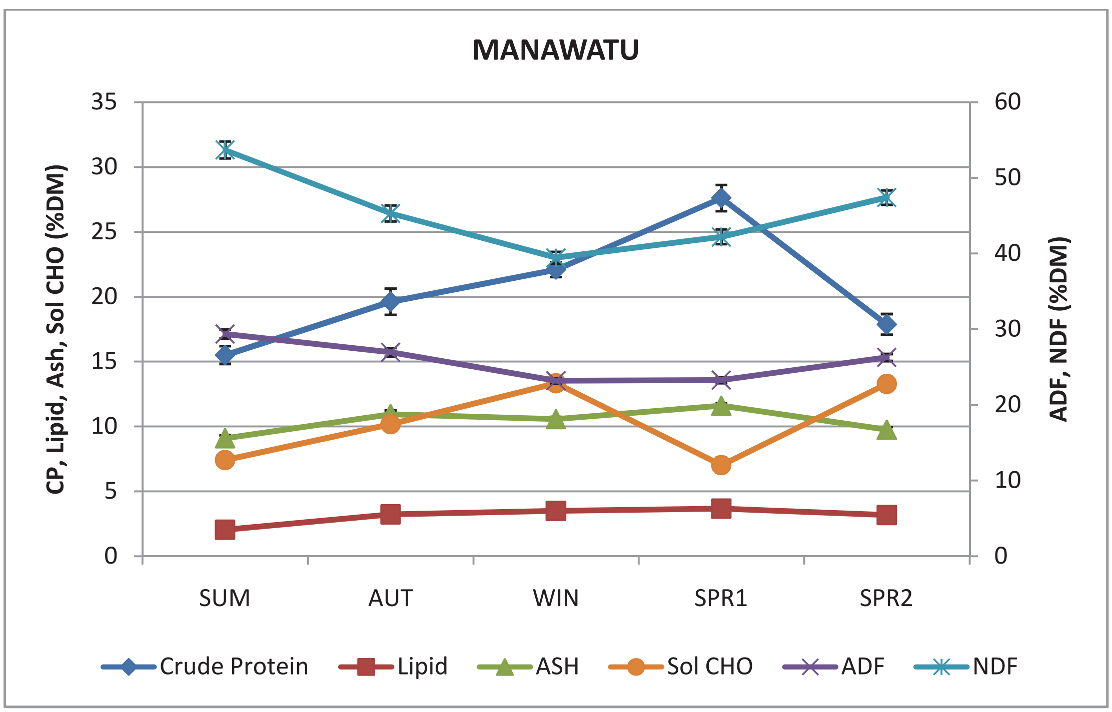


Figure 3.16: Seasonal variation in chemical composition for stud farms in the Manawatu region during the 2008-2009 breeding seasons.

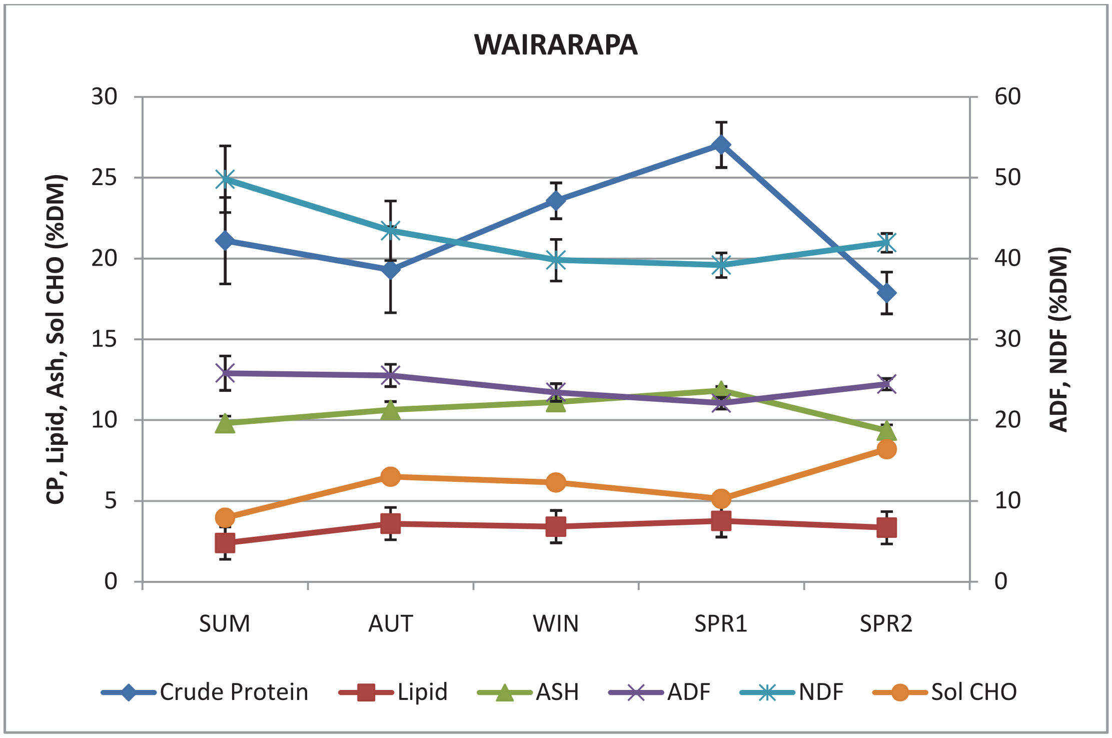


Figure 3.17: Seasonal variation in chemical composition for stud farms in the Wairarapa region during the 2008-2009 breeding seasons.

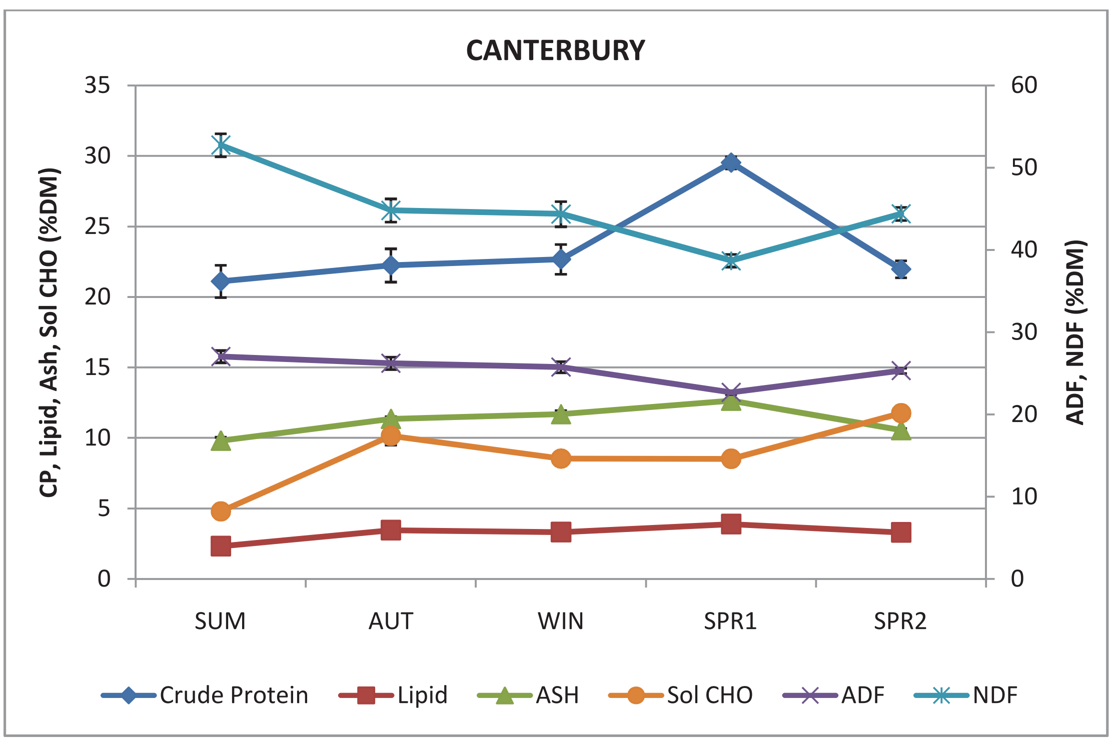


Figure 3.18: Seasonal variation in chemical composition for stud farms in the Canterbury region during the 2008-2009 breeding seasons.

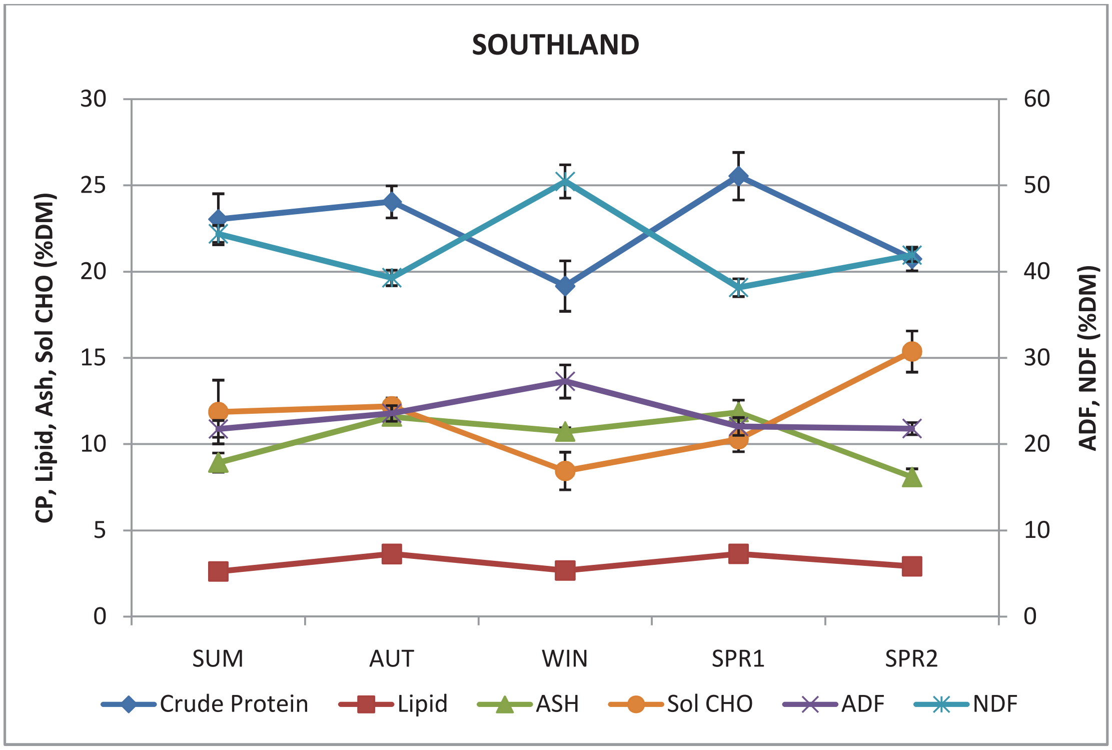


Figure 3.19: Seasonal variation in chemical composition for stud farms in the Southland region during the 2008-2009 breeding seasons.

3.5 Discussion

According to data obtained from the NIWA database (section 3.2.1), the climate during the study period was close to historically what is expected (no extremes such as drought-like conditions), and the annual rainfall was similar to the data for the 30-year averages. Therefore, the pasture data collected during this study should be considered to be typical of a normal seasonal pattern.

Larger commercial breeding farms were the sampling frame for the pasture study as this provided the opportunity to quantify the pasture use and composition of farms managing the majority of the broodmare and foal population in New Zealand. It was also recognised that many smaller properties which produce bloodstock often operate under a different management system. These properties generally operate primarily as dairy or sheep and beef units which require different pasture management strategies designed for the primary business, rather than for bloodstock production, which was the focus of this study.

Within the breeding farms the paddocks included in the study tended to be the largest on each property. Small paddocks and yard areas inhabited by yearlings and bloodstock used for sales preparation stock were not considered to provide sufficient pasture nutrition and were excluded on this basis. Many of these areas are constantly overgrazed and are primarily intended as safe, controlled smaller areas for exercise where most of the nutritional needs of the bloodstock are being met by preserved forages and cereal based concentrate feeds, not from pasture.

The main indicator of pasture quality is metabolisable energy, (ME MJ/kg DM), which shows a seasonal pattern, with higher levels observed in spring and late spring which associates well with the nutritional demands for the mare late pregnancy and her subsequent re-breeding. The ME content then drops to its lowest over the summer period, before starting to climb again once the autumn pasture begins to grow. The late summer and early autumn periods bring additional nutritional challenges to the breeding farm as it is traditionally the period when foals are weaned and the ME levels in the autumn pasture are generally lower than ME levels observed in winter and spring. This lower level of forage quality is normally offset at weaning by the provision of commercially prepared weanling diets with the main aim of preventing any growth checks in the young horses.

The quality of green grass leaf is lower in autumn than spring. For ruminants, it is well established that grass leaves growing at high temperature (as in autumn) would have higher fibre content and lower digestibility than leaves of the same maturity growing at a low temperature (as in winter and spring) (Wilson & Ford 1973). The horses unique digestive system comprises a foregut (stomach and small intestine), and a hindgut (caecum and large intestine), which is specially adapted for the digestion of fibrous forage (Janis 1976). This could possibly mean that an increase in fibre levels may not be as nutritionally compromising for horses. Studies in the area of digestibility and utilisation of digested nutrients of fresh forages for horses is scarce (Hoskin & Gee 2004), and further research in this area would be very useful to understanding the feeding value of particular forages for horses.

As expected the proportion of dead matter present in the sward has a direct effect on forage quality with low ME levels in summer (high dead matter) and correspondingly high ME (low dead matter) in early spring followed by a slight drop in late spring corresponding to the increase in dead matter measured in this period (Figure 3.20). Figure 3.20 shows the pasture data gathered during this study These findings are in line with other pasture studies conducted during a seasonal period in New Zealand (Litherland *et al.* 2002).

The almost four-fold increase in dead matter in the summer period was complicated by the fact that some regions due to higher rainfall and the use of irrigation, managed to maintain a higher ME and low dead matter in their pasture compared to those properties which had elevated levels of dead matter and lower ME values. There were a small number of paddocks in the study during summer which had recently experienced intense grazing pressure and while there was still some green growth there was a large amount of dead matter at the base of the sward.

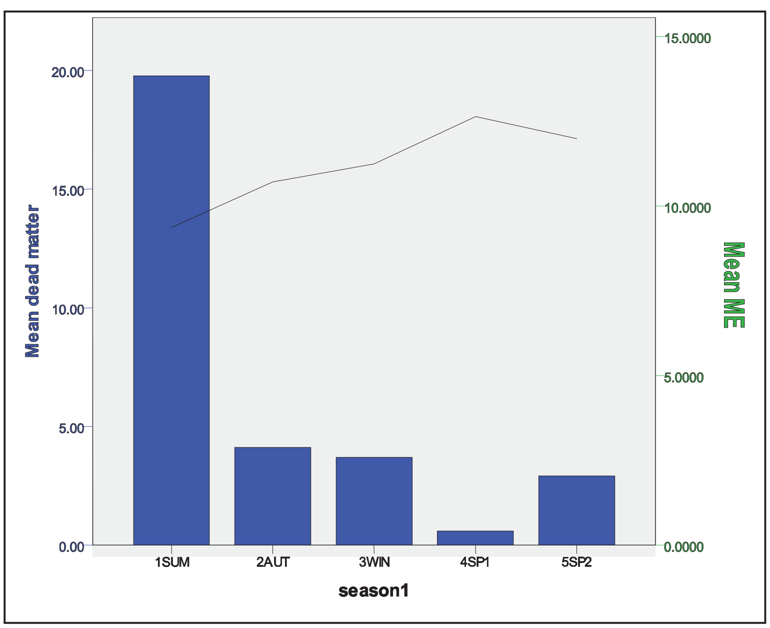


Figure 3.20: The relationship between ME and proportion of dead matter in the pasture.

Pasture samples collected in February were collected before the majority of rainfall was recorded, falling in late February. Subsequently the pasture collected during February was typical of summer pasture, (containing a higher level of dead matter, low ME and soluble carbohydrate levels than other seasons), excluding those breeding farms where irrigation was utilised (Wairarapa, Canterbury and Southland).

Irrigation provided a regular supply of moisture to the pasture during warm periods, helping to offset the decline in the ME of the pasture by growth of leafy green pasture with a reduction in the accumulation of dead matter typically found in summer pastures. Irrigation generally starts in late spring (November), and provides higher quality pasture for longer and decreasing the reliance on the feeding of conserved forage and cereal based concentrates. All three regions that irrigated did not show the same decrease in ME (stayed above 10 MJ ME/kg DM) whereas, Manawatu, Waikato and South Auckland, typically fell below 9.0-9.5 MJ ME/kg DM during the summer period (see Figure 3.11). Without access to irrigation, the breeding farms in the Canterbury, Wairarapa and Southland regions may have to rely more heavily on conserved forage to meet the nutritional demands of the bloodstock during periods of pasture shortage. However, in most regions breeding farms tend to provide conserved forage and cereal based concentrates so the impact of the reduction in pasture quality and quantity is not as obvious as it would be in a pasture-only system.

The use of irrigation would significantly increase overheads to those breeding farms using it and would need to be offset against the cost of conserved forage and cereal-based concentrates which would otherwise be needed during feed shortages.

The changes in chemical composition of the sward are brought about by the increasing photoperiod in spring triggering the reproductive growth phase of grass which if left uncontrolled, can lead to a residue of low-quality stem material in autumn that further lowers ME (Waghorn & Barry 1987). Dead matter also accumulates at the base of the sward when the senescence rate rises at high temperatures in combination with the reduction in the breakdown of senescent tissue which is slowed in dry conditions (Litherland *et al.* 2002).

Lower nutritional value (decreased ME), was found in pastures which have been left to get too long before grazing, resulting in the poor utilisation of the pasture asset. During the study photographs were taken at each paddock sampling to assist in the interpretation of pasture data. Unfortunately no measurement of accurate pasture height or mass was taken during the study. At each paddock sampling notes were taken on the approximate pasture height.

Following defoliation, pasture plants which were previously too long/rank take much longer to recover as a high proportion of stem is left behind, affecting pasture yield. It also results in the opening up of pasture, encouraging the growth of undesirable pasture species and weeds. Often there is a practice on breeding farms of shutting up paddocks in preparation for the breeding season. This practice will be detrimental to the growth and yield of a healthy plant and has a direct effect on pasture utilisation, with a high level of wastage from trampling.

The excess pasture could be managed by producing baleage which could then be used in a time of feed shortage (correctly preserved baleage is a superior source of nutrition for animals), or sold off to other farming operations (Dairy), which would provide a source of income to the breeding farm to offset the cost of feed bought off-farm. Other stock could also be bought in and fattened and sold once the excess is under control. The management of pasture at optimum levels will encourage a high yield of a dense healthy sward, assisting in the prevention of undesirable pasture species becoming established, and ensure that forage quality (high ME, low dead matter content), is kept at an optimal level.

A comparison of data from Litherland & Lambert (2007), (Figure 3.18) shows similar seasonal trends in the metabolisable energy concentration found in pasture to data gathered during the 2009 equine pasture study. The main variation is the drop in ME during the November period which was not observed during the same period for the 2009 equine pasture study. This could be a result of all South Island properties in the 2009 equine pasture study utilising irrigation. The data gathered in the earlier study (2007) was over a much greater number of pastures than for the 2009 equine pasture study. However, it does validate that pasture found on equine breeding farms is very similar in chemical composition and nutritional value to the pasture found on sheep, beef and dairy pastures during different seasons in New Zealand.

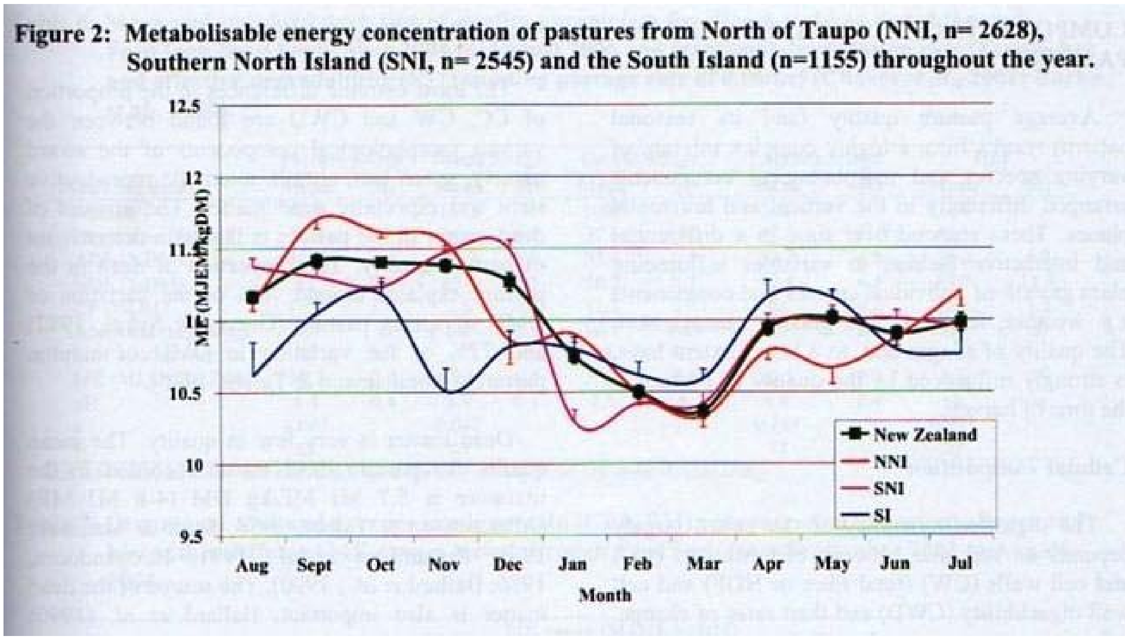


Figure 3.21: Adapted (Litherland & Lambert 2007).

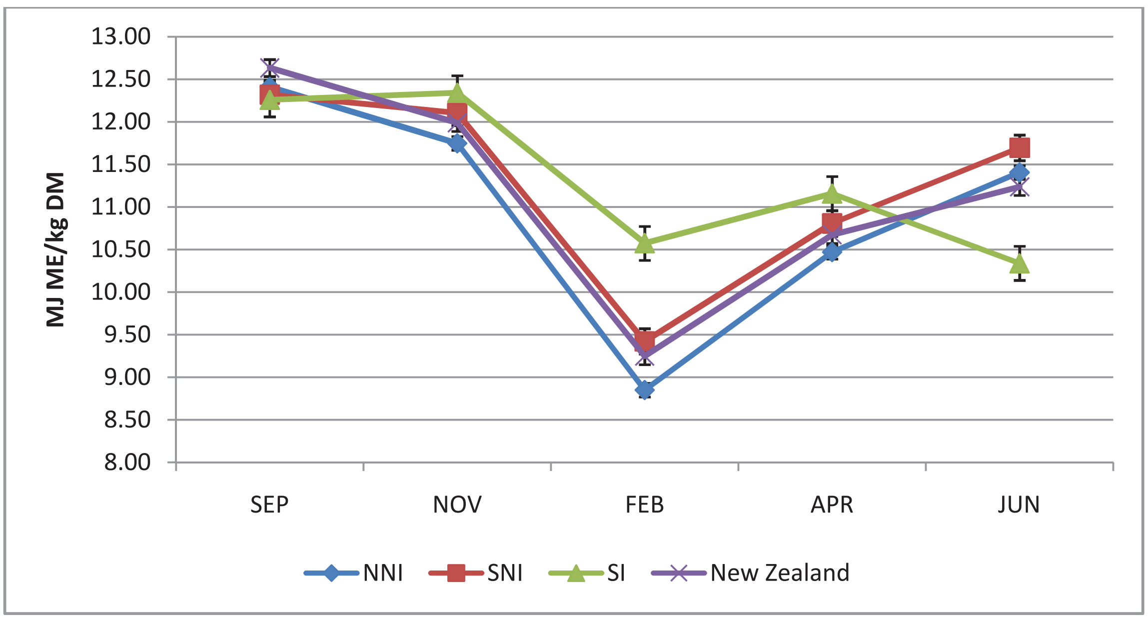


Figure 3.22: Metabolisable Energy concentrations of pastures north of Taupo (NNI), Southern North Island (SNI) and the South Island (SI) throughout the 2009 pasture study.

The dietary requirement of CP for growing horses and broodmares is outlined in chapter 2, (Table 2.5). The CP concentration of pasture in this study (Figure 3.22) and that of Litherland & Lambert (2002) (Figure 3.21), were, in most instances, surplus to that required by the grazing mare and foal. Once again the comparison of the trends between the two pasture studies showed very similar changes in CP levels over the seasonal periods (Figure 3.23 and 3.24).

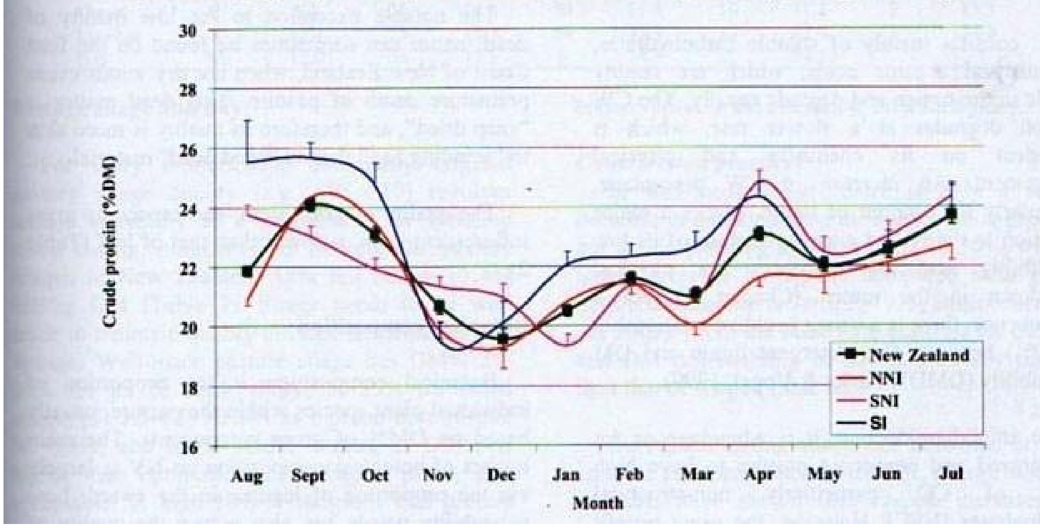


Figure 3: Crude protein concentration of pasture tested North of Taupo (NNI, n= 2628), Southern North Island (SNI, n= 2545) and in the South Island (n=1555) throughout the year.

Figure 3.23: Adapted (Litherland & Lambert 2007).

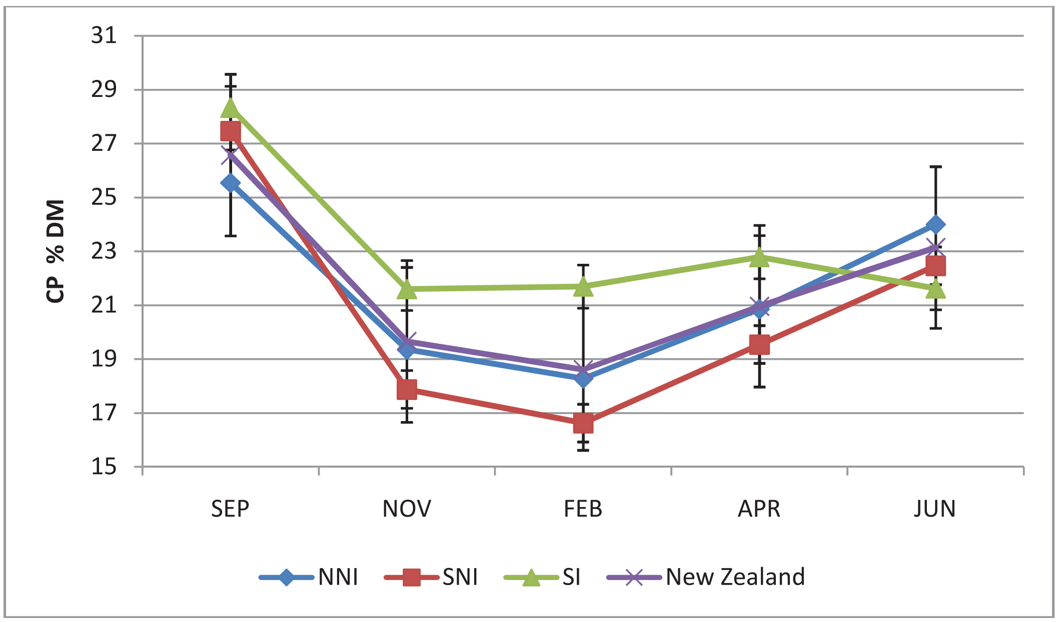


Figure 3.24: Crude protein concentrations of pastures north of Taupo (NNI), Southern North Island (SNI) and the South Island (SI) throughout the 2009 pasture study.

Fibre levels and soluble carbohydrate levels showed a seasonal effect, with higher levels of fibre in summer and autumn, while soluble carbohydrate were at a low level in summer (high levels of structural carbohydrate), but reasonably stable through autumn, winter and spring. As expected a newly sown pasture (Italian ryegrass) produced the highest soluble carbohydrate level of the study (19.5% DM). There are no known studies to date which examine the physiological effects on the horse from diets high protein and/or high soluble carbohydrates. Excess soluble carbohydrate could be associated with periods of rapid growth, and potentially the expression of DOD's and would be undesirable in horses.

Overall pasture botanical composition was complex, with the individual breeding farm accounting for some of the variation, while seasonal effects and the different climates of the regions producing some interesting results. The contribution of ryegrass to the sward was similar across all regions except for Southland which showed a decrease in the winter period (where other regions showed an increase). Ryegrass showed its persistency under colder wet conditions and contributed upwards of 80% to the sward in winter, dropping back to around 40% of the sward in the summer. Other grass cultivars were more prevalent during the warmer periods as were legumes, both of which decreased during the colder months of the year.

The climate of each region had an influence on how quickly 'warmer season' grasses and legumes became established in the sward. These were slow to establish in Southland and Canterbury, but during the summer months as a result of irrigation higher levels of legume in the sward exceeded that found in northern regions despite the southern locality. Manawatu also experienced a colder spring which delayed the growth of legumes in the sward. However, without irrigation into summer, the contribution of legumes to the sward was less than that of the farms which used irrigation. The higher daily temperature and rainfall of the South Auckland region kept the level of legume high in the sward.

The contribution of weed present in the sward appeared to be more prevalent the further north the farms were located. Weed growth while showing a similar seasonal trend contributed less to the sward moving southwards. This would have pasture management implications for those northern properties where weed control is possibly more important and for longer periods of the year. It is worth noting that between individual studs there was considerable variation in the degree of weed found in the pasture.

3.5.1 Actual pasture data and recommended nutrient requirements (NRC)

The National Research Council (NRC) nutrient requirements for horses are based on published data sourced from horses fed conserved forage and grain-based diets which are in direct contrast to the New Zealand pasture based farming system. The daily requirements have been calculated using assumed feed intakes of 2.5% BW (DM) for lactating mares and growing horses and 2.0% of BW (DM) for all other classes. These daily requirements are considered to be the minimum requirement for each physiological stage (Anonymous 2007). Table 3.7 provides an indication of the daily DM requirement of different growth stages of the horse.

Table 3.7: Example of feed intakes.

Horse Class	Daily DM requirement (kg DM/day)
Broodmare - 500 kg	12.5
Weanling 4months – 168 kg	3.4
Weanling 6months – 216 kg	4.3
Yearling - 321 kg	6.4

Table 3.8: Nutrient content of pasture in study – comparison to literature

	Content			
	Energy	Crude protein	NDF	Soluble CHO
Pasture	MJ DE/kg DM	g CP	g/kg DM	
NZ Ryegrass + white clover pasture				
- Autumn[123]	10.8	222-254	386-418	68-76
- Winter[12]	11.4-11.2	222-268		
- Spring[123]	10.8-11.8	148-220	432-494	71-112
-Spring (leafy)[123]	12.0	220-236	438	85
- Summer (leafy)[12]	10.3	150-219		
- Summer (stalky)[12]	8.0	100		
North America				
Grass pasture cool season, veg.[4]	10.0	26.5%DM	458	
NZ Red Clover grass				
Pre-bloom[12]	11.0	230		
Full-bloom[12]	10.0	180		
NZ Ryegrass + white clover pasture				
2009 Pasture Study				
- Autumn[5]	10.7	210	434	105
- Winter[5]	11.2	231	432	109
- Early Spring[5]	12.5	266	390	110
- Late Spring[5]	12.0	197	465	123
- Summer[5]	9.3	186	558	51

[1]Hoskin&Gee (2004); [2] Hunt (1994); [3] Grace N (2005), [4]NRC Anonymous (2007)[5]Hirst 2010 unpublished.

All data gathered during the 2009 equine pasture study is comparable to data from other sources (Table 3.8), apart from data collected during the 2009 summer period which is a little higher (9.3 MJ ME/kg DM versus 8.0 MJ ME/kg DM) for stalky summer pasture. This average is based on all regions collectively – however as discussed earlier the breeding farms utilising irrigation were able to keep ME > 10 MJ ME/kg DM which would have contributed to the higher value. Protein levels were generally in excess of daily requirements.

The results from this study showed that equine breeding farm pastures were rarely deficient in energy, protein or fibre. The low energy content of pasture in summer and in some cases autumn was caused by high dead matter and reproductive stem content. This is likely to be the main limitation to animal performance, especially in regions where summer temperature is high, rainfall is low, forage availability is low and stocking rate is high. Consideration of the nutritional requirements are made on the basis that there is sufficient DM available for the bloodstock to consume.

Stocking rate and pasture management have the ability to have a large influence over the quality and quantity of nutrient available to the grazing equine. Chapter four investigates pasture management practices on the 26 breeding farms which participated in the 2009 equine pasture study.

Chapter 4
Survey of pasture management on commercial Thoroughbred and Standardbred farms in New Zealand

4.0 Introduction

The equine breeding system in New Zealand is orientated around the constraints of an August 1st official birth date which imposes the start of the breeding season. The desire to have foals born close to this date is largely commercially driven, with the aim of producing larger and well grown mature yearlings for the annual sales. This is in contrary to the sheep, beef and dairy production systems which are designed around maximal DM pasture production. On equine breeding farms the mares arrive at stud early in the season (before maximal DM production), so that they can be bred or foal down and subsequently re-bred, to ensure the next foal is born close as possible to the August 1st date the following season.

Therefore, most commercial equine breeding farms in New Zealand experience a period during early spring and into early summer where extraordinary stress is placed on the pasture, with stocking rates in excess of numbers found during the late autumn and winter period, (Rogers *et al.* 2007, Goold 1988). This is a major issue for pasture management on equine farms in NZ. The late winter (August), and early summer period (November – December), of this intense stocking rate also coincides with the period which can be limiting in terms pasture production and quality. This is an inevitable part of the business operation as a result of the imposed breeding season. The Thoroughbred system is further constrained by the requirement that mares must be naturally covered, (artificial insemination (AI), is not permitted). This involves large movement of breeding stock onto commercial breeding farms. The Standardbred system permits AI, however many of the large commercial breeding farms also experience a considerable influx in mares early and across the breeding season, because they operate as breeding/AI centres.

De-foliation and overgrazing of desirable pasture species during periods of overstocking also opens up the pasture and encourages the growth of weeds, most of which are undesirable to horses and tend to flourish if not managed correctly. This happens with all livestock if they are able too. Uneven grazing eventually reduces the 'actual' grazing area if not managed - limiting the total pasture utilisation.

It is possible to maximise the amount of pasture DM with the use of suitable pasture management techniques but the constraints of the equine production system make some of these impractical and less effective (for example, rotational grazing). Safety and handling are a key objective of grazing bloodstock as horses are capable of moving at much greater speed than sheep or cattle and can take fright in a split second which greatly increases the risk of injury.

Where sheep and cattle are farmed for their meat, wool and milk, horses are farmed for their athletic ability thus any management practice (e.g. rotational grazing), which increases risk of injury is undesirable. Some equine breeding farms do use practices such as break-feeding behind an electric tape to increase pasture/crop utilisation seemingly without any problems related to safety of the grazing bloodstock. However, this is normally restricted to dry mares and older horses.

There is little recent documented literature about pasture management on commercial equine farms in New Zealand. Quantifying current practices of how pasture is managed on equine properties may reveal if the valuable pasture resource could be used more efficiently.

4.1 Materials and methods

4.1.1 Sample

The aim of the pasture management survey was to establish current management strategies aimed at providing and maintaining quality pasture to horses on commercial equine breeding farms in New Zealand. The selection of equine properties is outlined in chapter 3, (see 3.1.1).

The breeding farms that were interviewed for the pasture management survey were those taking part in the 2009 pasture study. The breeding farms surveyed were located across NZ, and comprised a mixture of Thoroughbred and Standardbred breeding farms. Larger commercial breeding farms were the sampling frame for this project as this provided the opportunity to quantify the pasture use and composition of farms managing the majority of the broodmare and foal population in New Zealand. The properties identified as commercial TB properties were related to actual clusters found in the Waikato region>Auckland>Manawatu>Canterbury >Wairarapa>Otago, reflecting the distribution of TB operations/activities reported in the 2008 NZ Racing Facts and Figures (Anonymous 2008b). The number of Standardbred breeding farms clustered in the Canterbury region are greater than Southland >Auckland =Waikato, reflecting the industry distribution (Anonymous 2008a).

During the winter collection (June/July 2009), a questionnaire was carried out to establish general pasture management practices on each stud farm. The studmasters/farm managers were contacted by phone or email in advance of the winter period to arrange a suitable time and date for the interview. All the breeding farms were sent a copy of the questionnaire with their pasture results from the previous period so that records could be referred to prior to the interview, if required.

The survey was designed to provide more detailed information on pasture management so that any differences between breeding farms and seasonal changes in pasture quality might be explained at the conclusion of the study. It was also intended that the survey would identify pasture management practices which are commonplace or perhaps those which might be useful to the wider equine production system in NZ.

4.1.2 Survey

The questionnaire consisted of 34 open, closed and multiple-choice questions. The questionnaire consisted of 12 sections examining farm size, number of stallions standing, the pasture renewal programme, pasture selection, management practices, stocking rates, pasture related diseases, the numbers of breeding stock and details relating to the level of supplementary feeding practiced at the different growth stages. Fertiliser included commercially available products (liquid and solid), and compost-based preparations. A copy of the questionnaire can be found in the appendices.

The survey interview was carried out by the researcher conducting the 2009 pasture study. During the interview the studmaster's responses were documented on a pro forma recording sheet created specifically for the questionnaire.

4.1.3 Statistical analysis

Data were plotted and presented as cross tabulations to examine for outliers and transcription errors. Parametric data were examined using a univariate general linear model. Non-parametric data were examined using PASW Statistics v18, (SPSS Inc Chicago IL, USA), with a significance level of $p<0.05$. Bonferroni post hoc test was applied to multiple comparisons.

4.2 Results

4.2.1 Land size

The effective farm size (area available for grazing), ranged from 40 to 567 ha and averaged 184 (SE±24) ha. Around half (12/26), of the farms were categorised as medium-sized (100-200 ha), 9/26 were large farms (≥200 ha), and 5/26 were moderate sized farms (≤100 ha). The total land area used by the studs participating in the pasture survey was 4,788 ha. Most of the land was owned by the stud operation with only 7% of the total area utilised being from leased property.

The number of stallions standing on each property ranged from 0 to 9 (median 3). A little over half of the farms (15/26), stood 2-4 stallions. A few farms did not stand any stallions (4/26), as these farms operated as breeding centres, either as AI centres (SB) or as 'walk-in' type properties.

The farms surveyed were responsible for 5,710 broodmares (TB n = 4,210 and SB n= 1,550 broodmares), which equates to approximately 52% of the registered TB broodmares during the 2007-2008 breeding season and 38% of the registered SB mares from the 2006-2007 breeding season. There were 2,519 TB and 1,130 SB foals which equated to 61% and 41% of the TB and SB foals registered in the 2007-2008/2006-2007 breeding seasons, respectively. There were also 1,188 mixed-age TB stock and 120 mixed-age SB stock on the properties surveyed, the majority of which were retained from the annual sales.

4.2.2 Stocking Density

Table 4.1 shows the average number of animals per hectare (density), on the surveyed breeding farms. Of particular note is the greater stocking pressure observed during the breeding season (August – December). Typically numbers of mares on the farms during the breeding season reduce by approximately one half to two-thirds the numbers present during winter. An idea of total stocking level on each stud equals the sum class of horse as given in Table 4.1.

The data for this table was gathered during the pasture management survey and thus relies on accurate reporting of numbers present on the stud farm as given by each particular farm.

Table 4.1: Stocking density (bloodstock/ha) for all stud farms in the survey.

Class of stock	Average per ha	Min per ha	Max per ha
SPRING/SUMMER			
Mare/ha	1.26±0.14	0.4	3.2
Foal/ha	0.8±0.09	0.1	2.1
Mixed-age/ha	0.31±0.04	0.1	1.1
WINTER			
Mare/ha	0.64±0.06	0.4	1.8
Weanling/ha	0.41±0.06	0.1	1.5
Mixed-age/ha	0.16±0.03	0.01	0.6

Figure 4.1 below shows the horse density data as stock units/ha, (where 1SU = 1 breeding ewe (Coop 1965). The stocking density rates have been calculated using the following assumptions.

- One mare and foal is equated to 14 SU
- Weanlings and mixed-age stock have been assigned 10 SU
- These assumptions have been adapted from the document, 'NZ code of Welfare for Horses'.

Most properties showed a decrease in stocking level outside of the breeding season, although 'stud four' appeared to increase stocking level in winter

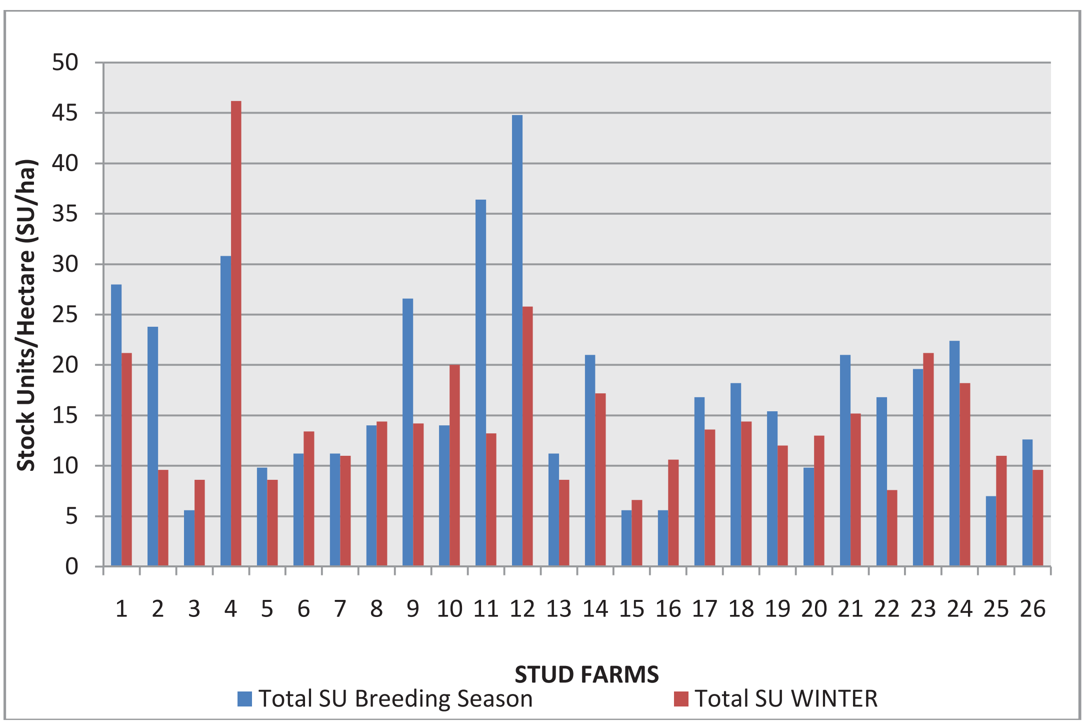


Figure 4.1: Stocking density on the 26 breeding farms. The numbers present during the breeding season (August – January) versus the winter period (May –July)

4.2.3 Breeding farm size and stocking density

Table 4.2: Effect of breeding farm size and stocking rate (bloodstock/ ha), where moderate < 100 ha, medium 100-200 ha and large >200 ha.

Parameter	Moderate ≤ 100 ha (n = 5)	Medium 100-200 ha (n = 12)	Large ≥ 200 ha (n = 9)
SPRING/SUMMER			
Mares/ ha	**1.91**±0.45 (0.5-3.3)[a]	**1.02**±0.13 (0.4-1.9)[b]	**1.22**±0.21 (0.4-2.6)[b]
Wet mares/ ha	**0.99**±0.25 (0.30-1.5)	**0.67**±0.10 (0.2-1.2)	**0.82**±0.18 (0.1-2.1)
Ratio wet to dry mares	**1.45**±0.33 (0.6-2.3)	**2.90**±1.18 (0.0-11.0)	**2.38**±0.96 (0.0-9.0)
Mixed age/ ha	**0.54**±0.14 (0.3-1.5)[a]	**0.29**±0.04 (0.1-0.5)[b]	**0.21**±0.03 (0.1-2.1)[b]
WINTER			
Mares/ ha	**1.02**±0.22 (0.5-1.8)[a]	**0.58**±0.05 (0.4-0.8)[b]	**0.51**±0.05 (0.4-0.8)[b]
Weanlings/ ha	**0.76**±0.21 (0.2-1.5)[a]	**0.38**±0.04 (0.2-0.6)[b]	**0.25**±0.04 (0.1-0.4)[b]
Mixed age/ ha	**0.26**±0.09 (0.1-0.6)	**0.18**±0.04 (0.1-0.6)	**0.08**±0.01 (0.01-0.1)

NOTE: Within a row, averages with different superscripts are significantly different, $P < 0.05$.
±SEM = standard error of the mean.

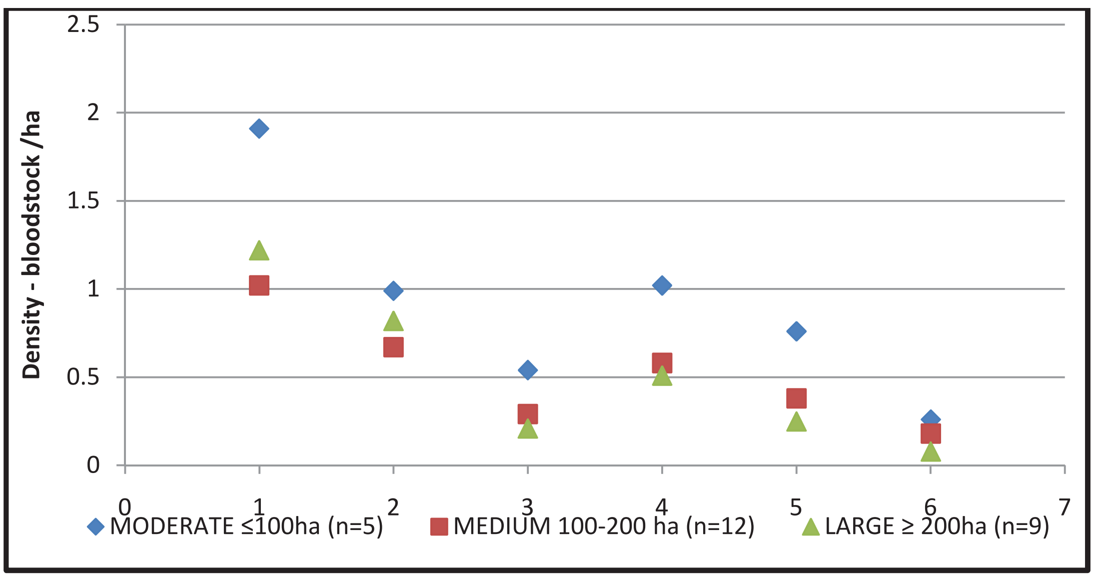


Figure 4.2: Relationship between farm size and bloodstock density

Note:
1 = Breeding season mares/ ha
2 = Breeding season wet mares/ ha
3 = Breeding season mixed age stock/ ha
4 = Winter mares/ ha
5 = Winter weanlings/ ha
6 = Winter mixed age stock/ ha

The most common reason for keeping all classes of horses in small regular cohorts was safety. The constant alteration of groups can result in increased danger during the initial settling in period for horses by comparison to traditional production animals. The ease of handling and convenience was also a large driver in the management of groups of horses on each farm. Horses were generally kept in a particular paddock until grazing was limited. The decision to move them onto new pasture was not clearly defined and not based on any known grazing residual level.

4.2.4 Typical paddock size and horse stocking density

Paddock size was relative to the overall size of each farm. Larger farms tended to have paddocks (range 3-8 ha), while moderate farms tended to have smaller paddocks (range 1-3 ha), (Table 4.3). The groups of mares and foals, weanlings and yearlings were generally reflected in the size of the paddock.

The average paddock size across all breeding farms has been analysed on the basis of the overall land size of the farm where; moderate = ≤100 ha; medium farms 100-200 ha; and large farms ≥200 ha.

Table 4.3: Average paddock sizes and numbers of bloodstock 2008-2009 breeding season.

Moderate Farms ≤100 ha		
Average paddock size (ha)	Dry mares	Wet mares (foal at foot)
1	5	5
1.21	7	4
2.43	5	4
2.43	7	5
3.03	9	5
Medium Farms 100-200 ha		
Average paddock size (ha)	Dry mares	Wet mares (foal at foot)
1.82	9	6
2.02	10	6
2.02	10	10
2.43	7	4
2.43	6	6
3	15	6
3.03	20	15
3.05	13	7
3.64	15	10
4.04	10	10
4.04	10	5
4.5	20	10
Large Farms ≥200 ha		
Average paddock size (ha)	Dry mares	Wet mares (foal at foot)
2.22	6	6
2.5	10	7
2.83	12	8
4.04	55	11
4.04	15	10
4.45	10	4
5.46	13	4
6	20	20
8.09	25	20

Review of the data showed that farms with larger paddocks housed more horses. Those breeding farms with paddocks grazing large numbers of horses were more likely to practice rotational grazing/break feeding – as opposed to set-stocking, particularly during the winter period (dry/pregnant mares). This type of grazing management was more prevalent on the larger breeding farms than on the medium and moderate-sized breeding farms.

Numbers of dry pregnant broodmares which were grazed together varied considerably. Most farms kept regular stable cohorts of horses, while a small number of farms kept the mares in large – to very large groups (> 20 - 40 horses), during the winter period. These larger groups of horses had access to more than one paddock and were moved around the property more like traditional livestock. Pasture utilisation was high in these situations with low residual pasture cover left after each grazing period. One breeding farm strip grazed a large group of mares on a winter green-feed crop. Strip grazing was not common when mares had foals or for groups of young-stock.

Post foaling, mares and foals were kept in the same, but generally smaller groups. The groups of mares and foals groups were approximately 30% smaller than the numbers found in a winter set-stocked group. Horses were generally set-stocked on most farms during the breeding season from foaling through to weaning (August – March).

Weanlings were in similar sized-groups to the mares and foals, but with the addition of one 'nanny' mare. Across the 26 farms, yearling colts lived in much smaller paddocks (large yards) while yearling fillies were kept in smaller groups appropriate to the size of paddock. The colts were separated largely for safety reasons, ease of handling and sales preparation.

The data from the survey found that the large breeding farms had a stocking density over the breeding season that was twice to three times that of the winter period (Table 4.2, Figure 4.2). Medium sized breeding farms tended to reduce stocking density during the winter period but to lesser degree by comparison to the larger farms. The farms with the highest stocking density across the year were mainly from the moderate with a couple of medium-sized farms also having high stocking density. Interestingly the moderate–sized farms (the smallest < 100 ha), had grazing intensity almost double that of the medium and large sized farms. The grazing intensity on the moderate farms was at the same level during winter as was found on moderate and large sized farms during the breeding season.

A small number of breeding farms actually increased their stocking density over the winter period, this increase coming from higher numbers of young-stock being wintered – or retained after the sales period, as opposed to the numbers of wintering broodmares. Again the smaller properties tended to have much higher stocking densities of young-stock/mixed-age stock than was found on the larger farms.

Figure 4.3 shows the average daily pasture growth rate (kg DM/ha) in three regions of New Zealand. These data are taken from analysis of high-producing dairy pastures (www.dairynz.co.nz), so average DM production on perennial-type pastures would be expected to be slightly less. All regions show a similar profile of DM production, with northern regions producing higher levels of DM per day during the late winter to late spring period of intense stocking pressure. The stocking intensity of each farm was not related to a predicted level of DM production. Rather, it was dependent on the individual stud farm and the stocking intensity pressure each one had from a business perspective.

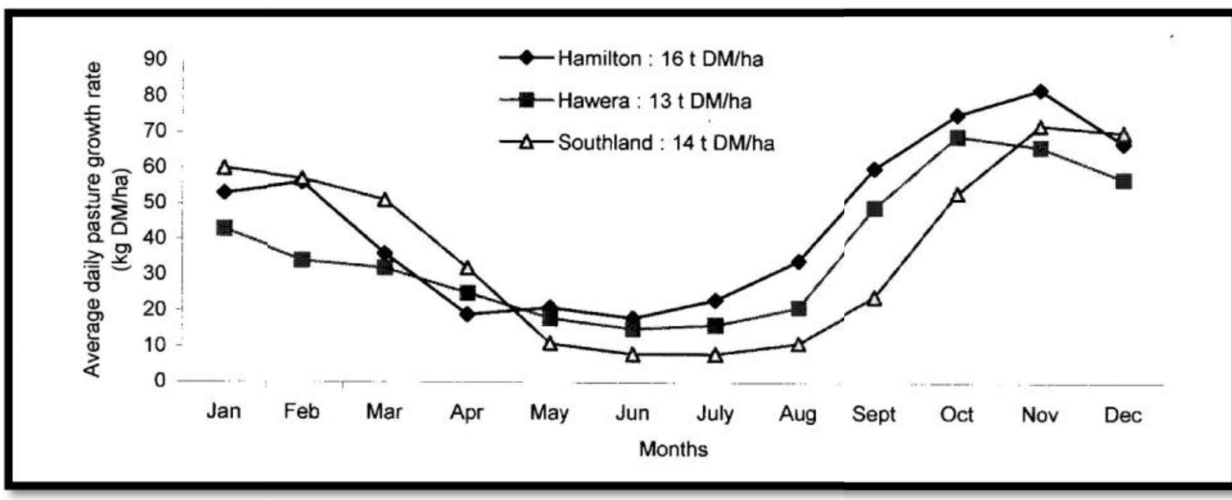


Figure 4.3:Regional average daily pasture growth rates (kg DM/ha) (www.dairynz.co.nz).

4.2.5 Pasture renewal plan

The majority of farms (22/26), had some form of pasture renewal/maintenance planned for their farm. The remaining group, (4/26) had no pasture renewal plan, but commented that pasture renewal was conducted infrequently and as a consequence of a climatic event – e.g., post drought or after heavy pugging during a wet winter.

A high rate of pasture renewal (every 1-3 years), was planned on 3/26 farms. Most farms had a more conservative renewal programme of every 3-5 years (10/26 farms) and every 5-10 years 9/26 farms.

The reasons given for pasture renewal were; the harsh grazing behaviour of the horses (7/26), poor pasture performance (11/26), drought (3/26), control of undesirable pasture plants (12/26), and to increase DM production for the high stocking period during the breeding season (18/26).

Most pasture managers could not quantify the proportion of grasses, legumes, weeds or pasture herbs currently present in the pasture on their farm. Many were also unsure of the distribution of high endophyte versus low endophyte ryegrass on their property (8/26).

The most commonly used professional service by the farms was that of a fertiliser representative (23/26), followed by seed company representatives (18/26). The services of a nutritionist (2/26), farm consultant (3/26), and agronomist (2/26) were not as highly utilised by most breeding farms.

4.2.6 Grass species sown in the new pasture

For those farms which carried out pasture renewal, the sowing of annual and perennial ryegrass in an 80:20 traditional production blend with white clover was the most common across all farms surveyed (19/26). Farms that finish lambs and cattle tended to sow higher performing cultivars such as ryegrass hybrids and Italian ryegrass, grown specifically for that purpose (11/26). A small number, (n = 4-6) farms used ‘other’ grass cultivars in their pasture seed mix, which included fescue, cocksfoot, prairie grass, phalaris and timothy.

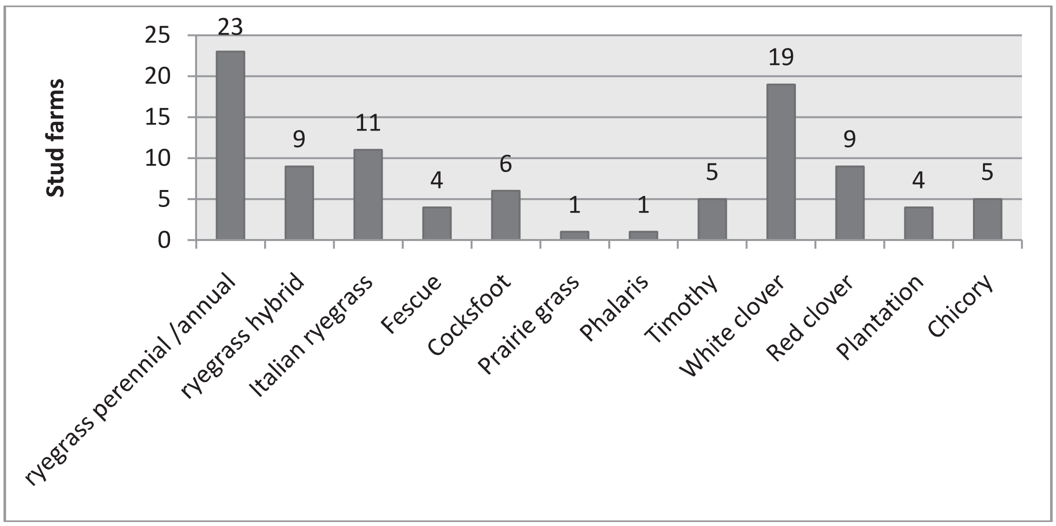


Figure 4.4: Pasture plants sown during pasture renewal.

Of those farms which carried out pasture renewal, 6/26 farms chose high endophyte ryegrass and 15/26 farms chose low endophyte ryegrass in their pasture seed mixes.

4.2.7 Pasture management

4.2.7.1 Pasture management practices

Figure 4.5 shows the various pasture management practices which were considered in this survey. The use of cattle for cross grazing was more common (22/26 farms), than for sheep (13/26 farms). Most of the farms used the other stock to clean up the pasture after the horses had been in the paddocks (24/26 farms), a smaller number of farms had other stock grazing with the horses (7/26 farms) and some farms grazed paddocks with other stock (7/26 farms), before the horses were moved to the paddock.

The practices of harrowing, topping, weed-spraying, cross grazing, and pasture spelling was common across all farms (Figure 4.5). Harrowing was generally carried out during spring, summer and autumn, while topping and weed spraying was conducted predominantly during in the growing seasons (late August – late November). The use of other stock for cross grazing was largely year-round, with some farms (4/26 farms), using the growing seasons (excess pasture), to fatten lambs and/or cattle.

There was very little use of feed budgets and/or the estimation of pasture cover at any given time on any of the breeding farms in this survey.

Table 4.4 shows the various management practices in relation to farm size.

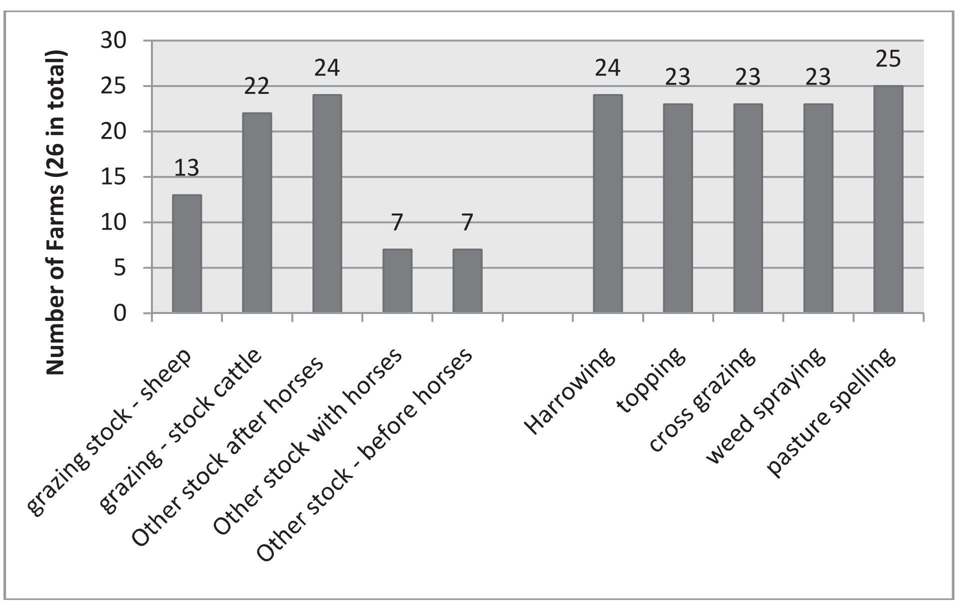


Figure 4.5: Pasture management practices.

Table 4.4: Number of farms applying various pasture management procedures related to farm size, where moderate < 100 ha, medium 100-200 ha and large >200 ha.

Pasture Management Practice	Moderate ≤ 100 ha (n = 5)	Medium 100-200 ha (n = 12)	Large ≥ 200 ha (n = 9)
Pasture renewal	4	10	8
Fertiliser applied	5	12	9
Fertiliser representative	5	10	8
Soil Testing < 2 years	4	9	7
Cross grazing – Sheep	2	7	4
Cross grazing – Cattle	3	11	8
Harrowing	5	11	8
Irrigation	1	1	3
Supplementary feeding	5	12	9

4.2.7.2 Irrigation

Without exception all farms in the South Island had access to, or frequently used, irrigation. One property in the lower North Island used irrigation frequently, while one lower North Island property had access to irrigation but did not use it. All other North Island properties relied on seasonal rainfall for pasture growth.

4.2.7.3 Fertiliser

Each farm had an individual approach regarding fertiliser application. Those who had employed the services of a fertiliser representative mostly had tailor-made fertiliser programmes for their particular property. Two farms routinely used liquid fertiliser, while (25/26 farms) used solid fertiliser.

Most breeding farms applied fertiliser on an annual basis (24/26 farms), with only two farms applying fertiliser less regularly than annually (applied every 1-2 years). As shown in Figure 4.6 some farms applied different fertiliser during different seasons of the year. Thirteen farms applied fertiliser once annually and the most common time was in the autumn, (11/26 farms). Twelve farms applied fertiliser twice annually, with autumn and spring applications more common (8/26 farms). Two of the 26 farms applied fertiliser year-round. These two farms either had access to their own compost for top-dressing or top-dressed with liquid manure (sourced off farm). The type of fertiliser applied was generally a commercial preparation, with the concentration and blend unique to each farm. Cropmaster®, Dicalcic phosphate (dcP), superphosphate and lime were the most commonly used products on the breeding farms.

Trace elements were added to fertiliser mixes on (9/26) breeding farms. Urea was used routinely on (5/26 farms) to boost DM production during growth periods.

Soil analysis was carried out within the last 12 months by (18/26 farms). Two farms have conducted soil analysis within the past 1-2 years. Six farms haven't conducted soil analysis for a period greater than three years.

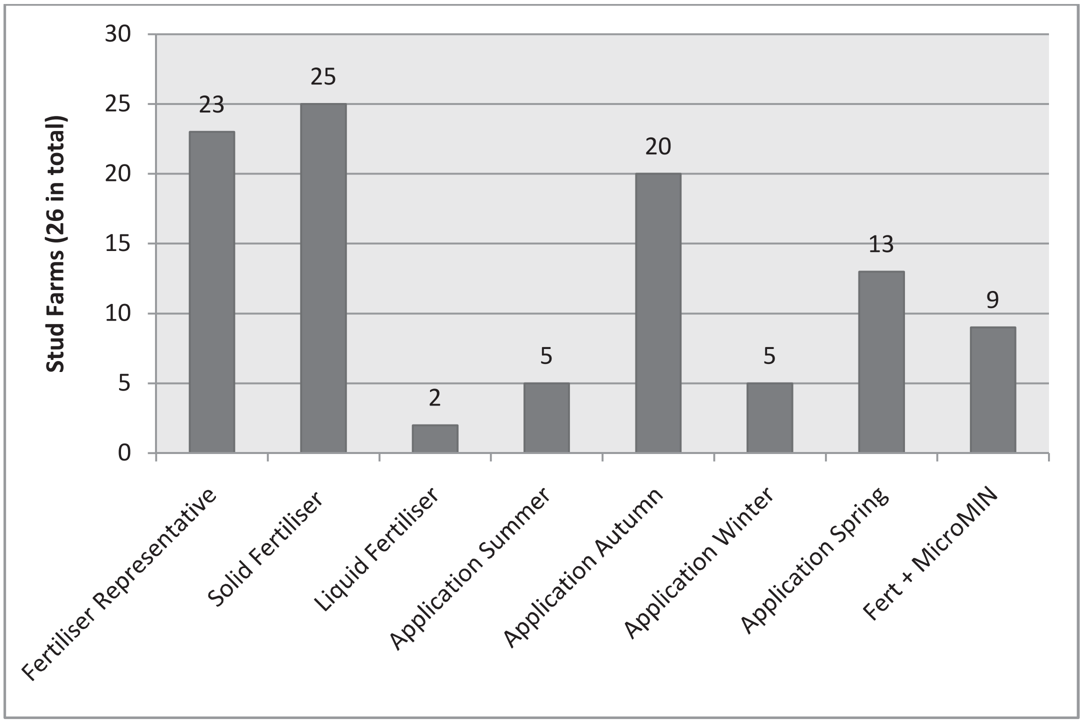


Figure 4.6: Fertiliser: type and frequency of application and the use of tailored fertiliser programmes.

4.2.8 Supplementary Feeding

The breeding farms varied considerably with the amount and complexity to which supplementary feeding was provided. It is not the purpose of this study to quantitatively determine how much each class of livestock was receiving, more to determine the type of supplementary feed used, the frequency and the classes of livestock that it was provided for and the reasons for providing supplementary feed.

The survey found that supplementary feeding was widespread across all farms in the pasture study, particularly during periods of low pasture growth (winter, drought conditions) and during the heightened period of stocking pressure in the breeding season. Each feeding programme was tailored to the particular class of stock, e.g., yearlings received a much higher proportion of supplementary feed (pre-prepared cereal-based feeds), than dry mares did, who largely relied on pasture to supply all of their daily nutritional requirements.

When asked if the decision to use supplementary feed was based on the difficulty of knowing if the horse is meeting its nutrient requirements from pasture, (7/26 farms) agreed, while (13/26 farms) disagreed. Those that disagreed, commented that they concentrate feed based on condition score to get a response that cannot be gained from pasture alone. The general consensus was that even if horses were pastured on a plentiful supply of quality forage there was still a tendency to use cereal-based concentrate feeds in the horses ration, particularly during sales preparation and training.

4.2.8.1 Mares (dry)

Dry mares, (empty or pregnant without a foal at foot), generally relied on pasture to supply their daily nutrient requirements. There was provision of mineral blocks to paddocks and during periods of low feed supply and climatically adverse conditions, hay, baleage/haylage were provided to assist in the maintenance of body condition. Concentrate feeding during this period was only supplied to individuals that were identified as in light condition and/or not in optimum health. One farm provided the mares with break-fed green feed crop of oat and Italian ryegrass/subterranean clover during the winter, which continued late into the final trimester.

4.2.8.2 Mares (last trimester)

Generally mares in their last trimester were given access to a commercially prepared formulation designed for use in this period (17/26 farms). These preparations are designed for the mares increased requirements of specific nutrients to ensure healthy foetal growth. The most commonly used commercially prepared supplement was 'NRM Mare balancer'. The quantity ranged from 0.5 kg - 4 kg per mare, depending on feed type and level of supplementation required.

Supplementation of pasture with baleage in the third trimester occurred on 19/26 farms, while meadow hay was provided on 7/26 farms during this period. Commonly the baleage consisted of traditional pasture, however there were a small number of breeding farms using lucerne baleage.

4.2.8.3 Mares (lactating)

The use of supplementary feeding was at its least frequent during the late spring/early summer period, largely due to the increase in DM production of pasture. During late spring and into summer, mares and foals were provided with ample pasture (normally to excess in ideal growing conditions). This was clearly reflected in the low number of breeding farms using supplementary feeding during late spring and into summer. Of the 26 breeding farms, 6/26, provided the mares with a cereal-based supplement feed, 7/26 farms, provided baleage and 2/26 farms, provided hay. Most farms commented that during a period of drought and for sick/unhealthy/confined mares that extra supplementary feed would be supplied to meet the deficiency in pasture DM. Of those who relied solely on pasture during this period a small number (3/26 farms), provided a mineral block/minerals *ad libitum* in the paddock. The minerals provided in a feeding tray were horse-specific, while the mineral blocks were more generic and intended for all grazing stock.

4.2.8.4 Foals

Very young foals at pasture relied largely on their dam's milk to provide their daily nutritional needs. With age the foals increasingly relied on pasture to meet their nutritional requirements. During periods of drought and low grass growth (e.g., towards the end of summer), it was common for additional preserved forage (hay, haylage), to be provided to mares and foals (25/26 farms). As weaning approached (late January to April), most foals were offered increasing amounts of cereal-based supplement feed to prepare for the weaning process.

4.2.8.5 Weanlings

Weanlings were typically offered a commercially-prepared cereal-based supplement feed designed for weanlings, both in the period leading up to weaning and the period post-weaning (22/26 farms). One farm reduced the cereal-based supplement feeding at weaning, increasing fibre and providing a mineral/vitamin mix to the weanlings at pasture. NRM Evolve was the most commonly used pre-mixed feed used by the farms. The amount supplied to the weanlings varied from 1 - 4 kg per day, increasing into winter and with weanling growth. Additional forage fibre was provided to weanlings in the form of hay (10/26 farms), and/or haylage (12/26 farms).

4.2.8.6 Yearlings

Yearling diets became increasingly complex as they were brought in, in the 6 - 8 weeks prior to preparation for the annual yearling sales held in late January/early February. Decisions regarding feed type and frequency were made by the stud/farm manager, and were occasionally in conjunction with a nutritionist and/or feed company (6/26 farms). Many of the feeding programmes were individualised for each animal and the decision was largely historically preference based on what has worked for them in their past experience. There seemed to be an acceptability that commercial supplementary feeding was essential for producing youngsters for sales (25/26 farms). If the yearlings were not intended for the yearling sales market, they were fed less commercially prepared cereal-based supplements, if any at all.

4.2.9 Nutrition disorders associated with pasture

A range of nutritional disorders were profiled where pasture nutrition can be a contributing factor. These included mineral imbalances, DODs, and ryegrass staggers. DODs were concern number one for (10/26 farms); mineral imbalances number concern for (8/26 farms) and ryegrass staggers (10/26 farms). Three of 26 farms chose both mineral imbalances and DODs as equal number one concern to them. Three farms were not concerned about any of the above conditions.

When asked if they had observed ryegrass staggers in mares, (21/26 farms), answered ‘yes’. Clarifying comments included that ryegrass staggers was generally seasonal in nature, the stud/farm managers perceived that there was very low incidence 1-5 % on their farm, and that it was a management issue for those mare/s which exhibited symptoms.

When asked if they believed that DODs were a problem for the breeding industry in New Zealand, (17/26 farms) agreed and (7/26 farms) disagreed. X-rays are commonly used as a screening tool for certain types of DOD, particularly in the lead up for the annual yearling sales. Thus, it was more of a problem for those animals destined for the yearling sale market, but not so important for selling racehorses already proven on the racetrack.

When asked if they believed that the main aim of the industry was to produce a yearling of desirable size for the yearling sales, (14/26 farms) agreed and (7/26 farms) disagreed. Those that disagreed clarified by commenting that the main aim of the breeding industry is to produce athletic racehorses that win races, and that fast racehorses come in all shapes and sizes. The selection and success in the yearling market doesn’t necessarily equate to performance on the track. A comment was made that from a business perspective success in the yearling market is desirable, but it shouldn’t be the main aim of the industry in New Zealand.

4.3 Discussion

The sampling frame for this survey was limited to those participating breeding farms in the 2009 pasture study. The survey did not include the many small breeders who manage only one or two mares. The majority of the commercial breeding farms in New Zealand were included in this survey, and as such it provides a relatively accurate impression of the pasture management practices carried out on commercial Thoroughbred and Standardbred breeding farms in New Zealand.

For the Thoroughbred breeding farms the larger properties tended to be located in the Waikato/South Auckland regions. All the Standardbred properties had a significant investment in land and were located in the South Island. A number of North Island Standardbred studs were invited to participate in the pasture study, but declined involvement, therefore were not surveyed.

The main pasture management issue for breeding farms is the intense grazing pressure experienced at the height of the breeding season. From late winter through to late spring, the stocking density of breeding farms can be very high, which places additional strain on the maintenance of quality pasture and the challenge of matching the energy/nutrient supply and demand of the horses.

The larger farms (based on land size) experienced less grazing pressure during the breeding season, than the smaller farms. However, across all breeding farms the comparison of stocking density was likely to be due to the individual studs operation, rather than adhering to any given ‘stocking rate’. There was no pattern of stocking density relating to region or ability of the region to grow higher levels of pasture DM or pasture on farms which had modern high-producing (DM) cultivars.

Many of the larger farms had a large influx of client’s horses, which are not present on the breeding farm outside of the breeding season (January – August). The stocking density on the large farms (≥ 200 ha), reduced by some around 60% outside of the breeding season, whereas medium sized farms (100-200 ha), tended to reduce stocking density outside the breeding season but to a lesser degree (40% reduction in stocking density).

The moderate farms (≤ 100 ha), had a stocking intensity almost double that of the medium and large farms, both during the breeding season and out of the breeding season. This shows that there is enormous pressure on these smaller properties to stock larger numbers of bloodstock, potentially so that the economic viability of the business is guaranteed via the throughput of numbers. This applies both in numbers of mares to the stallion/s and to mares foaled-down on the stud farm.

The breeding farms which increased their stocking density over the winter period was a result of the higher retention of young-stock being wintered – or retained after the sales period, as opposed to the numbers of wintering broodmares. Again the smaller properties tended to have much higher stocking densities of young-stock/mixed-age stock than was found on the larger farms. This could reflect that the larger farms were more 'commercial' since it was less likely for them to retain a significant young-stock numbers beyond the yearling sales.

A small number of the stocking densities on the breeding farms were relatively high – even by dairy farm standards (where 3.5 cows/ha is considered high, Holmes *et al.* 2007). Two of the breeding farms had stocking density over 3 mares/ ha. This is of particular concern given that horses have different grazing characteristics to cattle and that the pasture quality and quantity on horse breeding farms was generally not managed to the same degree as dairy farms to maximise DM production.

On the breeding farms surveyed the horses were set-stocked for longer periods of time (particularly mares with foals), than would be ordinarily found on traditional production farms, which places additional strain on pasture. Set-stocking on breeding farms is largely a safety precaution, due to the significant risk of injuries which could occur when bloodstock are moved around. Horses are flight animals which can travel at much greater speed than sheep or cattle - taking fright in a split second and run which greatly increases risk of injury. As horses are bred primarily to be athletes, any management practice which increases risk of physical injury would be undesirable and could present a significant cost (loss) to the breeding farm. Cattle and sheep do not move at the same speed as horses and are bred for milk, wool and meat, thus minor injury does not present a significant potential loss to the same degree. However, the farming of deer does present a greater risk due to the degree of flighty-ness and thus management practices for the movement of deer are different to sheep and cattle.

As a result of set-stocking, practices found on traditional production farms, such as break feeding or strip grazing and rotational grazing were less likely to be used on the horse farms surveyed. There were only two farms which used an appreciable amount of break feeding, and this tended to be outside the main breeding season (when there were no foals or very young-stock present).

A small number of breeding farms moved horses to new pasture based on sward height, but this was less common during the high-stocking rate pressure which occurred during the breeding season. The movement of horses to new paddocks was more under the control of feed availability in those new paddocks than driven by an objective measurement of feed availability in either the current paddock or the fresh paddock.

The numbers of mares and foals housed in any given paddock tended to reflect the safety elements of grazing bloodstock, rather than being related to the capacity for pasture DM production. Groups of mares and foals and young-stock are generally kept together and only moved as a group to minimise the risk of injury. The amount of DM present in any given paddock is not often measured to check that there is sufficient/or an excess of DM available for the animals present. Most breeding farms were able to rest pasture to allow it to re-grow, however the rotation length was often shorter than would be recommended (particularly during periods of high stocking density). One of the surveyed breeding farms did not have the capacity to rest any pasture due to its stocking density during the breeding season.

A particular issue of horses is that they are selective grazers, which has a significant effect on overall pasture utilisation and future sward persistence. Horses spend much of their time walking around trampling pasture as opposed to cattle and sheep. Galloping horses also damage pasture by tearing up the soil and pasture with their hooves (Hunt 1994). Pasture which has been continually grazed to ground level and damaged will be slower to recover and struggle to persist under some conditions.

Equine breeding farms often saved paddocks to produce a heavy sward of pasture in preparation for mares and foals. However this generally failed due to the deterioration of the pasture plants, especially at the base and the poor recovery which followed grazing (Wallace 1977). This degree of pasture cover not only slows down the pasture growth, both in the DM potential of the pasture, and the opening up of the sward for weed growth to occur (Grace *et al.* 2002b). This ultimately results in poor utilisation of pasture, in addition much of the available nutrition is trampled and wasted.

Pasture on some the breeding farms during September - November was found to be 15 to 30 cm in height. On one such breeding farm which had saved pasture for mares and foals (> 40 cm deep), was left with stalky and patchy pasture after the mares and foals had been through it. An example of the before grazing and post grazing pasture if shown in Figures 4.7 and 4.8. Much of the pasture had been trampled which would have represented a real loss in terms of valuable feed. The nutritional composition when analysed was much lower in this paddock and it took much longer for this paddock to recover than those paddocks which had been kept in the growth phase. It would have also allowed for the growth of weeds due to the opening up of the pasture at soil level.

Pasture heights for all paddocks were not measured with a rising-plate meter as such, but comments regarding pasture cover were recorded at each sampling site and photographs taken of each paddock sampled.

Figure 4.7: Before grazing (early spring). >12.5 MJME/kg DM; 32.8 %CP; 0% dead matter.

Figure 4.8: Post grazing (late spring). High level of stalky and dead matter/opening up of pasture base. 11.2 ME/kg DM; 16.8 %CP; 53.6% dead matter.

Higher utilisation of pasture could be achieved if paddocks were break fed. This practice is relatively uncommon on breeding farms, but could be used successfully with high visibility electric tape. It would provide more control over the pasture by minimising wastage due to trampling.

During these high DM production periods, it is also possible to keep the pasture in the leafy stage for as long as possible during the growing season by topping and/or cross grazing with other stock. These practices help to maintain maximal pasture DM production and increase the quality of the sward. Another option would be to conserve the excess DM as haylage or baleage for later use when feed demand outstrips DM production. This excess could also be sold off as an extra income source to offset high cost of grain-based feeds commonly used on breeding farms.

By cross-grazing with either cattle and/or sheep it is possible to maintain pasture an even height and density in the sward, also ensuring the grass/pasture plants which are not palatable to horses don't become dominant in the sward. Cattle and sheep also re-distribute nutrients necessary for healthy pasture growth by virtue of the fact they eat the rank growth and the distribution of their faeces and urine is indiscriminate (Wallace 1977).

Sheep are potentially a better combination with horses as they are more indiscriminate than cattle regarding the re-distribution of nutrients. Sheep are also less likely to cause pugging damage during periods where pasture growth is limited and rainfall is high. However, the use of sheep on equine properties is not always practical as they require a different fencing design than is often found on most breeding farms. They are also more time-consuming to care for (shearing etc). The main advantage is their lighter bodyweight (compared to cattle) and they do a more efficient job of nutrient transfer and cleaning up roughs in paddocks. The optimal pasture cover for sheep is also much lower than it is for horses and cattle.

Enhancing soil fertility by applying solid and/or liquid fertilisers and the renewal of pasture species to more productive persistent varieties are practices which can be applied to increase pasture DM, particularly during the periods of high stocking density. Regular soil fertility tests were common place on most breeding farms. They assist in maintaining an environment where productive and desirable pasture species can flourish and ensuring animal health and production is not compromised by soil fertility problems and low yielding pasture plants. As the horse manure in paddocks is normally confined to the 'roughs' the fertility transference and the even spread of fertiliser to enhance soil nutrient levels is not easily solved, particularly for those properties which have high stocking densities (Goold 1991).

Pasture renovation plans varied considerably over the 26 breeding farms. Some had very ambitious plans to renew entire farm over a three-year cycle. In reality this would mean that one-third of the available pasture land each year would be involved in cultivating new pasture plants, which would put enormous pressure on the stocking density. Most farms had a more conservative renewal cycle over 3 to 5 years or 5 to 10 years, which would be more realistic in terms of affecting the amount of grazing land available to bloodstock at any given time. Pasture renewal is an important part of overall management ensuring that optimum forage quality and growth rates are achieved.

There were very few breeding farms which used grass cultivars other than the standard ryegrass/clover mix. The pasture species used for pasture renovation were predominantly ryegrass and clover in an 80:20 mix. This pasture mix is the traditional choice for dairy farms in the same regions due to its persistence and high yield of DM (Rogers *et al.* 2007). However, these are not the species of choice for horses with regard to palatability and because many of the perennial ryegrasses still contain the naturally occurring endophyte *Neotyphodium lolii*, which is associated with grass staggers in horses (Hoskin & Gee 2004).

In recent years, low-endophyte ryegrass cultivars have become available and are more 'horse friendly' and less likely to cause staggers and disturb production than traditionally used cultivars (Hoskin & Gee 2004). However of the 26 studs surveyed, not all chose low-endophyte ryegrass for their pasture and many were of the opinion that ryegrass staggers was not a huge problem for the industry. Most commented that one in 100 mares could be affected. Although the diagnosis of ryegrass staggers in grazing broodmares and young-stock would be difficult at pasture unless they were exhibiting easily recognisable clinical signs of the disease. These clinical signs would be from those animals which are severely affected. Many animals may have sub-clinical conditions and observation at pasture would not necessarily identify those at risk of the condition.

The use of other grasses (other than ryegrass), was minimal – surprising given some can produce useful yields of DM. Other grass cultivars are known to have a higher proportion of structural carbohydrates than modern ryegrass cultivars and legumes. Whether more fibrous grasses are beneficial for horses remains largely unknown as digestibility for different cultivars of grasses in horses is not well understood and research is scarce. Most information is anecdotal and not based on trials conducted with scientific rigour.

Many of the breeding farms expressed an interest in what grasses would be best for sowing into horse pastures so that nutritional needs could be met in addition to maintaining high a DM production. Modern grass cultivars used in traditional systems are generally faster growing producing more DM per hectare (higher in soluble carbohydrates), may not be as appropriate for the equine (in relation to their digestive system). However, managed correctly in a balanced ration they may provide sufficient nutrition from pasture alone.

Harrowing was commonplace on the breeding farms despite being risky for exposure to parasitism (Hunt 1994). Unless harrowing is carried out with knowledge of the life cycle of the parasite in combination with cross grazing with another species it is likely to expose the horses to significant risk of parasitism. The practice of harrowing was carried out to largely assist with fertility transference, but also for aesthetic reasons. Large areas of lawns and roughs quickly become untidy if not managed on horse farms. Most breeding farms were most concerned with the paddocks and areas around the entrance (for presentation) and less concerned about pasture beyond the stables and/or presentation areas. Generally the manure pats of horses on a high forage diet (pasture and hay) have the slowest breakdown rate. Birds can assist in the breakup of manure pats (Goold 1988), but this is normally when manure contains appreciable amounts of undigested grains.

The use of irrigation on some breeding farms showed that the quality of pasture could be maintained during periods when rainfall was limiting. This enabled higher DM production on land that otherwise may not produce sufficient DM to meet demand, particularly during the summer months. Inevitably this comes at a cost to the business, thus increasing operational costs to the breeding farms. There is no detail as to whether the use of irrigation is cost effective, but it could be partially offset by the high cost of providing supplementary forage during the dry season.

Giving animals accurately measured and controlled quantities of feed, calculated to meet their daily requirements is a basic feature of all intensive animal production systems. However, it is more difficult to measure the intake of horses so a stud farm can't be sure if the horses are being given the appropriate level of feeding (Holmes *et al.* 2007). There was a high reliance on cereal-based supplements as an additional feed source to pasture in different periods of the year. The type and degree of supplementary feeding was related to the age and stage of the horse. The period of least use of supplementary feed was September through to January for mares and foals.

While there were many similarities in pasture management between the breeding farms surveyed, there also existed some different approaches to pasture management over the group of twenty-six breeding farms. Some of these differences in management were interesting given the tightly defined production goals of the TB industry (Rogers *et al.* 2007). One farm made its own compost (used straw from bedding, combined with manure which had been collected from the smaller paddocks on the farm). This was mixed, aged and then re-spread on the pasture. Another farm used a green-feed crop of short rotation ryegrass and oat which was break-fed to the mares during the winter period. This allowed other paddocks on the farm to be rested in readiness for the breeding season. The same farm applied pig effluent via a tanker from a local piggery to the pasture as a source of fertiliser.

Most Thoroughbred breeding farms agreed that commercially there is significant pressure to present the 'ideal sized/framed' youngster at the annual yearling sales. This requirement often poses a direct conflict with the nutritional management of the young growing horse and the potential for DODs to be expressed. It is a inconsistent aim - since the ultimate aim of the industry is surely to produce a healthy and sound racehorse without the pressure for maximal to growth during its first year of life. Interestingly the Standardbred breeding farms were less concerned with meeting the yearling market and more focussed on producing bloodstock which can succeed on the racetrack.

Important questions to arise of this study are:

- How important is pasture as a source of nutrition to the equine production system in New Zealand?
- Are there practices which can make better use of the breeding farms most valuable asset in land and growing feed?
- Is pasture utilised to its full potential or simply seen as a place to exercise where a high input of supplementary nutrition is acquired from conserved forage or commercially prepared feeds?

One thing that is clear is that the investment in land these breeding farms have is an expensive asset thus should be fully utilised. Pasture management could be more comprehensive (as it is in dairy farming systems), and thus provide sufficient nutrition to broodmares and young growing horses.

While in the traditional farming system certain practices ensure a high level of quality forage DM is offered to grazing stock, perhaps the direction the equine industry needs is that, it needs to be more innovative to ensure profitability and its specific needs for horse nutrition are met through more efficient use of the pasture resource.

Chapter 5
Seasonal pasture quality and pasture management on commercial Thoroughbred and Standardbred farms in New Zealand
General Discussion

5.0 Introduction

This general discussion outlines the major findings and relates the pasture compositional data to the information gathered in the pasture management survey. This is done under the headings of: the provision of quality forage to grazing bloodstock in New Zealand; the management of pasture quality under seasonal pressure; and pasture management practices to assist in the maintenance of pasture quality and quantity.

The discussion concludes with recommendations for the efficient use of pasture within the equine farming system in New Zealand and areas where further research could be focussed.

The original objectives for the studies described in this thesis were to:

- Provide baseline data on the seasonal variation in pasture quality by analysing the chemical and botanical composition of pasture on a selection of commercial equine breeding farms in New Zealand (Chapter 3).
- Review the pasture management practices on equine farms in New Zealand (Chapter 4).
- Compare data from the pasture study to the published nutritional requirements of growing horses to determine if pastures offered to growing bloodstock in New Zealand are sufficient for healthy growth and performance (Chapter 3).
- Interpret pasture management strategies in combination with pasture quality data (Chapter 3 and 4.

The objectives of this research were achieved by the gathering of a complete set of data which shows the seasonal changes in pasture quality on commercial equine farms in New Zealand. The pasture data is complemented by detailed information relating to the management of pasture on these equine farms.

The compositional data gathered during this study showed that equine breeding farm pastures were rarely deficient in energy, protein or fibre. The low energy content of pasture in summer and in some cases autumn was caused by high dead matter content and reproductive stem content. This is likely to be the main limitation to animal performance, especially in regions where summer temperature is high, rainfall is low and stocking rate is high. Consideration of the nutritional requirements are made on the basis that there is sufficient DM available for the bloodstock to consume at all times.

5.1 The provision of quality forage to bloodstock in New Zealand

The predominant feed source for New Zealand broodmares and foals is pasture, mostly consumed directly from the paddock, but also following conservation as baleage, haylage and hay. Grazed pasture is very different from other sources of feed such as conserved forage and cereal-based supplements, because pastures must re-grow, time after time, to provide the horse's feed next week, next month and next year.

Therefore good grazing management must also be good feeding management, and it must cater for the present and future needs of both the pasture and the horses (Holmes *et al.* 2007). The nutritional status of the broodmare is a factor in the reproductive performance of the mare as poor and inadequate nutrition can lead to reduced reproductive efficiency in the mare.

From a business perspective, the requirements of producing a live healthy foal every year is crucial as mares which fail to conceive within a 25-day window post-partum eventually have to forgo a mating season which is costly to the business which relies on the sale of a young horse each year (Bosh *et al.* 2009). Thus, the supply of a balanced ration which ensures adequate nutrition for each situation is important to maintaining the production cycle.

5.2 Management of pasture quality under seasonal (climatic) pressure

The quantity of feed required by a horse depends mainly on its size and age, its body condition and/or rate of growth, and whether it is pregnant or not. Consequently, the quantity of feed required for each physiological stage is altered by the quality of the particular forage. Factors affecting the quality or nutritive value (NV), of forages for horses include a decrease in NV for forages with increasing plant maturity (Darlington & Hershberger 1968, Hoskin & Gee 2004). It is well known that digestibility declines with forage quality (Duncan *et al.* 1990).

Feed quality can be attributed to seasonal changes in forage composition as pasture quality is dependent on the ratio of cell contents to cell walls and cell wall digestibility (Litherland & Lambert

2007). The amount of dead matter in the pasture is the main determinant of pasture quality and is typically influenced most by seasonal changes with pasture management also a contributing factor.

Pastures which have been poorly managed in addition to those under seasonal pressure in summer will have elevated levels of dead matter and long fibrous plant matter. Management during these periods is crucial for maintaining pastures of high quality for as long as possible, before climatic conditions result in a greater influence over forage quality. Figure 5.1 shows the seasonal pattern of forage quality. Maintaining pasture in the growth phase for as long as possible is crucial for retaining pasture quality. The digestibility and energy component of the pasture falls as reproductive and stemmy growth begin to appear.

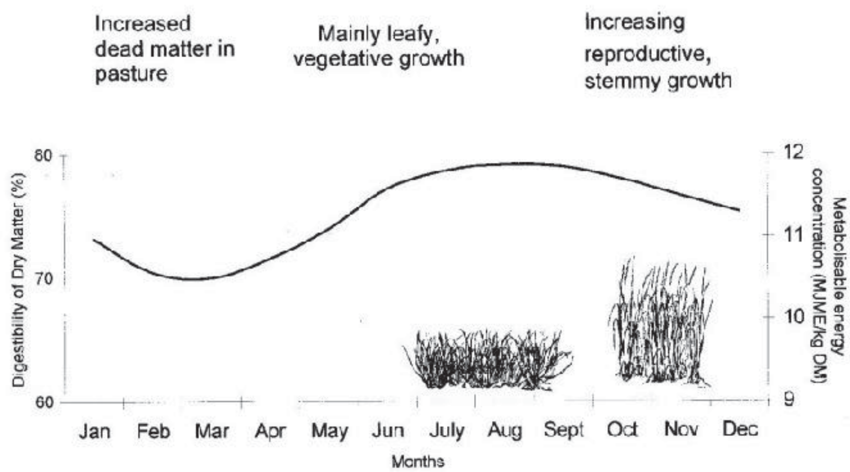


Figure 5.1: Seasonal pattern of forage quality (www.dairynz.co.nz).

The contrast in the seasonal pasture production in dryland and irrigated Canterbury farms (Valentine and Kemp 2007), demonstrates the negative effect of low soil moisture in summer on the potential pasture production as determined by temperature or thermal time. The use of irrigation in these dryland areas has made it possible to produce sufficient DM for grazing horses than would otherwise been impossible in these areas. The quality of the pasture during the summer and late autumn period was kept higher on irrigated properties, than the quality of pasture from those farms not using irrigation. However, the consequence of the high cost of irrigation is that a high return business is needed to make it profitable (Valentine & Kemp 2007).

5.3 Pasture management practices to assist in the maintenance of pasture quality and quantity

Horses by comparison to sheep and cattle are notoriously 'hard' on pasture which brings added challenges to pasture managers to maintain the nutritive value at a high level. Horses are reluctant to graze in areas which contain faecal contamination, which continues long after the faecal pat has disappeared. This creates patches of overgrazed 'lawns' and roughs containing under-grazed rank pasture. The selective grazing behaviour of horses' results in the undesirable/uneaten pasture plants eventually becoming dominant in the sward (Grace *et al.* 2002b). This is largely because horses have a tendency to return to the same preferred feeding site until it is overgrazed (Kruger & Flauger 2008). Horses will graze high-sugar grasses, such as ryegrass in preference to other grasses such as timothy, browntop and fescue (Hunt 1993). Overgrazing results in the loss of high fertility grasses like perennial ryegrass from the preferred grazing areas (Goold 1991).

The horse's uneven grazing habit eventually reduces 'actual' grazing area if not managed - limiting total pasture utilisation. Breeding managers must consider the pasture area which is actually available for grazing and the consequences this has on the most appropriate stocking rates for horses in any given property (Wallace 1977).

Cross grazing of other stock (sheep and cattle), can improve the quality and health of the pasture significantly. Not only by keeping the pasture at a height which maximises growth and yield, but also to assist in fertility transference and parasite management. Breeding farms tended to use cattle as cross-grazing stock, possibly as they are an 'easier care' option compared to sheep. However, sheep would be more beneficial since they don't do the pugging damage that the heavier cattle do to the pasture and soil in wet conditions and their fertility transference is more evenly spread in a paddock than cattle manure is. The extra stock can also be used as another income source to offset some of the high input costs due to conserved forages and cereal-based concentrates being an integral part of the equine production system.

The practice on equine breeding farms of closing paddocks to produce a heavy sward of saved pasture generally fails due to the deterioration of the plants, especially at the base and the poor recovery following grazing (Wallace 1977). During the 2009 equine pasture study the approximate pasture cover was recorded during the early and late spring periods. This showed (for the 3 paddocks on each breeding farm that were being sampled), that 65% of farms had at least one paddock which was 15-20 cm in pasture height, and 46% of breeding farms had a paddock with pasture height over 30 cm. The pasture height was not measured objectively as part of the study, however for each paddock sampled notes were recorded on pasture height/mass and photographs taken to assist with interpretation at a later date.

Higher utilisation of pasture could be achieved if paddocks were break fed. This practice is relatively uncommon on breeding farms, but could be used successfully with high visibility electric tape. It would provide more control over the pasture by minimising wastage due to trampling.

Historically, Goold (1997), recommends that pasture which is offered to horses should be grazed from a height of 20 cm down to a height of 8 cm. However, given more recent data for maintaining a high yield and production of a dense healthy sward, pastures should be grazed before they reach of height of 20 cm. At 20 cm there is likely to be significant wastage due to trampling and the pasture plants will also be slower to recover once defoliated. At a pasture height of 14 cm (3200 kg/DM ha), it is considered a surplus quantity and growth of the pasture slows and quality declines (Meat & Livestock, 2004).

Table 5.1 shows the indicative herbage mass found at varying heights of pasture. These values are indicative as seasonal differences in DM content (DM content is high in spring, lower in summer and autumn). Nevertheless they do provide a starting point where feed availability and stocking density can be considered. The development of a ‘sward stick’ for use on equine farms that was simple to use would also assist with management of the pasture resource. This type of resource would estimate the level of DM in a pasture by simple measurement. The DM levels are based on pasture density, growth stage and time of year. As with any of these types of measurements, they can only be considered estimates.

Table 5.1: Average height of green plants and the ‘indicative’ herbage mass.

Adapted from Primefacts 323 Bell A., (2006).

Average plant height (cm)	‘Indicative’ herbage mass (kg green DM/ha)
1	400
2	700
4	1200
6	1600
8	2000
10	2400
12	2800
14	3200

Note: Values indicative only – seasonal changes will vary DM content.

Information is scarce regarding the feed intake levels in the horse, and how variable these are in reality. Consequently without accurate information on feed intake it is difficult to assess if the horses nutritional needs are being met.

Taking pasture yields from pre-grazing pasture masses and post-grazing pasture residuals is one way of determining the 'apparent' intake of the horses. In addition, an estimate of pasture growth during the period between measurements is required. Unfortunately in wet weather and for very long pasture this method can be erroneous as trampling of pasture is not accounted for. Also horses tend not to graze the longer 'rank' pasture, concentrating on the shorter faster growing palatable areas which are devoid of manure. This where the use of 'trained eye' would be vital so that pasture cover is not over-estimated. Measurement of the pasture would require the use of a calibrated plate meter or an experienced 'trained' eye with the help of a 'sward-stick' or suchlike device. Estimating pasture cover can produce reasonably reliable and useful results, particularly if it is used frequently.

The development of a tool to assess pasture cover and estimate feed availability for the equine pasture manager would certainly assist in making informed decisions regarding the provision of sufficient pasture for the horses. It would also identify possible excesses which could be conserved and kept for periods of feed shortage or sold off to provide another source of income. It could also identify potential for grazing of cattle and/or sheep which contribute positively to overall pasture health and yield.

The use of supplementary feeding on equine breeding farms is commonplace, (Stowers *et al.* 2009), particularly from weaning-age onwards. A characteristic of all the sources of animal feed that are alternatives to pasture are that they cost more than pasture (Table 5.2), (Valentine and Kemp 2007). The availability, risk profile, quality and flexibility of alternatives to pasture vary, and costing them fully can be complex. Nevertheless, the cost of supplements relative to pasture is reasonably constant, with extra pasture grown with nitrogen fertiliser being the cheapest supplement and cereal-based supplements the most expensive (Valentine & Kemp 2007), (Table 5.2). The use of fertiliser to boost growth/DM yield is another relatively inexpensive way of increasing DM production.

Table 5.2: Cost of supplementary dry matter (DM) relative to pasture priced at 5 cents/kg DM. Adapted from: Valentine & Kemp 2007.

Feed Source	Relative cost
Pasture	1.0
N Fertiliser	1.5-2.5
Pasture silage	2-4
Maize silage	4-5
Hay	4-6
Cereal grains	6-12
Concentrates	6-12

The pasture renewal cycle on the surveyed breeding farms is quite variable. While some had very ambitious renewal programmes (every 3 years the whole property would have undergone some form of pasture cultivation), in reality this is likely to be less given that at least one-third of the farm would be under renewal each year which would place enormous stress on forage availability, especially for those with high stocking densities. Most properties reported between 5 - 10 year renewal cycles. Most of the pressure to renew pasture came from significant climatic events (e.g., drought), and the significant stress that grazing horses place on the maintenance of high quality pasture. There were a small number of breeding farms which did not conduct any form of pasture renewal.

In terms of species sown in pasture renewal programmes, these were very specific to each individual breeding farm, and most tended not to sow high yielding cultivars, opting to use traditional annual and perennial ryegrass in combination with a white clover. Many of the breeding farms expressed an interest in what grasses would be best for sowing into horse pastures so that nutritional needs could be met in addition to maintaining high a DM production.

5.4 Recommendations to the equine industry in New Zealand–related to pasture management

Overall the main message is that the pasture should be realised as a key asset for growing horses in New Zealand. Management tools which assist in maintaining pasture quality and quantity for horses for all physiological stages – rather than a place to exercise should be a clear focus of pasture managers on equine breeding farms. However, given supplementary feeding - particularly from weaning onwards is an integral part of the equine system the management of surplus pasture as a possible extra income source could be investigated to offset some of these supplementary feed costs.

By combining seasonal pasture compositional data and the estimation of available kg/DM ha in any given pasture it would be possible to determine if the pasture is potentially providing sufficient nutrition for the horses that it is intended for. This would allow pasture and stud managers to make better informed decisions regarding appropriate stocking densities and the requirement for supplementary feeding, particularly during times of feed shortages. It would also identify excess forage which could be conserved (retained for later use or sold off), and/or used to fatten dry-stock.

5.5 Further research

1. Develop software and/or pasture management tools for equine pasture managers which enable them to evaluate current feed levels which can then be balanced against current feed requirements as dictated by stocking density and the growth, age and stage of the grazing horses.

2. From the published data available information on the mineral content of horse pasture is scarce, whereas information on the mineral content of supplementary feeds is extensive. Mineral content of pasture is of particular interest as often it can be limiting for specific minerals. Concern regarding mineral imbalances was commonplace amongst those surveyed during the pasture study. Horses have specific requirements for a range of minerals at any given physiological stage. A deficiency in any one of these minerals can have implications for the growth of a healthy sound athlete. Much of the published mineral requirements have been extrapolated from ruminant studies and may or may not be applicable to horses given their different digestive system. The collection of pasture across distinct seasonal periods would allow for baseline levels of mineral content to be established. The pasture samples from the initial study have been dried and stored should the opportunity arise to analyse these in the future.

3. It would be useful for more detailed research to be carried out to establish feed intake levels in the horse, and how variable these are in reality. Without accurate information on feed intake it is difficult to assess if the horses nutritional needs are being met.

4. Properties producing bloodstock operate under a different management system to dairy/sheep/beef farms and an investigation into pasture species which are suitable for the equine production system (from a physiological point), would also be useful at some stage in the future. Whether more fibrous grasses are beneficial for horses remains largely unknown as digestibility for different cultivars of grasses in horses is not well understood and research is scarce. Most information is anecdotal and not based on trials conducted with scientific rigour.

Appendices

6.1 Botanical Composition – Raw data

	Ryegrass	Other Grasses	Legume	Weed	Dead Matter
Sth Auckland	% DM ±SE of the mean				
SUM	34.34±6.66	19.66±4.63	10.64±2.94	15.90±3.99	19.47±4.14
AUT	52.10±5.53	19.30±5.38	10.32±2.48	15.73±2.55	2.54±1.17
WIN	75.66±7.59	12.25±6.98	5.28±1.29	6.80±1.45	0
SPR1	54.03±8.33	16.27±5.43	13.68±3.15	15.98±4.34	0.05±0.05
SPR2	29.35±4.11	29.73±6.70	17.04±4.42	17.07±4.32	6.81±2.48
Waikato					
SUM	48.81±3.34	19.71±2.93	7.13±1.59	5.19±1.24	19.16±2.42
AUT	72.60±2.75	10.70±1.82	5.70±1.09	6.92±1.13	4.08±0.99
WIN	87.97±1.83	5.24±0.98	1.27±0.36	4.21±1.10	1.30±0.60
SPR1	74.60±2.75	7.40±1.78	4.51±0.73	13.48±1.79	0
SPR2	64.33±3.43	15.19±2.78	6.71±1.20	11.23±2.19	2.55±0.72
Manawatu					
SUM	21.57±3.84	17.16±4.54	23.57±4.44	3.32±1.34	34.38±4.52
AUT	52.36±3.67	23.11±5.48	19.10±4.80	1.60±0.64	3.83±1.52
WIN	73.99±5.68	18.61±5.85	4.83±2.12	1.91±0.89	0.67±0.49
SPR1	56.27±6.38	19.32±6.10	16.55±3.31	7.85±2.61	0
SPR2	63.68±8.37	18.31±7.04	8.05±2.09	4.80±1.43	5.16±4.43
Wairarapa					
SUM	46.39±6.43	13.19±7.63	17.46±11.32	9.23±1.04	9.23±1.04
AUT	66.58±5.56	16.03±7.26	8.78±5.70	4.92±0.33	3.69±3.69
WIN	84.82±5.27	8.11±3.66	1.59±0.98	4.46±2.47	1.03±0.68
SPR1	70.25±5.27	19.13±8.07	4.97±2.76	5.65±1.89	0
SPR2	64.45±5.01	16.87±9.12	13.22±3.63	4.77±3.18	0.69±0.69
Canterbury					
SUM	52.07±4.08	22.80±5.07	13.55±1.82	5.60±1.36	5.97±1.61
AUT	59.40±5.47	19.91±5.82	9.72±1.69	3.23±0.89	7.75±2.90
WIN	77.45±6.27	14.75±2.98	1.81±0.53	0.13±0.10	5.86±4.15
SPR1	76.59±5.65	15.12±5.89	6.88±2.15	1.22±0.38	0.19±0.13
SPR2	59.11±5.44	23.52±5.03	13.34±3.00	4.04±1.20	0
Southland					
SUM	36.75±6.25	6.37±1.56	25.79±10.77	1.02±0.79	30.07±10.94
AUT	60.02±5.79	16.19±5.22	22.25±3.72	1.53±0.63	0
WIN	54.86±12.53	12.99±8.10	2.65±0.73	1.30±0.36	28.21±8.31
SPR1	79.73±6.18	6.82±1.66	5.01±1.40	0.72±0.21	7.72±5.33
SPR2	51.10±7.17	34.57±7.94	12.31±4.49	0.83±0.28	1.19±0.42

6.2 Chemical composition – Raw data

	ME	CP	Lipid	Ash	ADF	NDF	Sol CHO	OMD
South Auckland	MJME/kg DM	% DM						
SUM	8.69±0.26	16.46±0.84	1.97±0.15	9.16±0.20	29.40±0.85	58.13±1.41	5.06±0.42	58.19±2.02
AUT	10.07±0.19	21.04±0.74	2.66±0.13	10.25±0.22	25.69±0.52	42.17±1.17	9.76±0.68	71.64±1.43
WIN	10.78±0.24	24.30±1.07	4.08±0.30	10.00±0.20	23.31±0.82	49.09±1.27	10.14±0.59	77.64±1.65
SPR1	12.30±0.08	26.48±0.61	3.46±0.09	10.62±0.21	21.34±0.26	39.81±0.55	12.07±0.83	86.51±0.73
SPR2	11.69±0.15	21.66±0.83	2.68±0.11	9.03±0.26	23.88±0.51	48.41±0.85	10.24±0.40	79.89±1.07
Waikato								
SUM	8.90±0.10	18.88±0.56	2.29±0.12	9.71±0.15	28.06±0.52	58.13±0.90	3.75±0.33	61.52±0.95
AUT	10.61±0.14	20.78±0.51	3.50±0.08	10.26±0.19	24.14±0.36	42.99±0.64	10.61±0.47	75.47±0.85
WIN	11.61±0.10	23.89±0.36	3.51±0.07	10.94±0.11	23.46±0.32	41.16±0.71	11.59±0.40	79.62±0.81
SPR1	12.44±0.03	25.22±0.53	4.03±0.06	11.06±0.15	21.32±0.26	37.93±0.53	13.19±0.43	88.92±0.51
SPR2	11.77±0.07	18.58±0.66	3.07±0.07	9.10±0.20	25.15±0.35	47.60±0.56	11.99±0.48	78.83±0.65
Manawatu								
SUM	9.21±0.13	15.50±0.68	2.05±0.09	9.10±0.20	29.36±0.59	53.66±1.13	7.42±0.51	62.50±1.49
AUT	10.63±0.19	19.62±1.01	3.23±0.07	10.95±0.28	26.94±0.57	45.29±1.05	10.18±0.44	73.28±1.55
WIN	11.73±0.17	22.09±0.58	3.50±0.09	10.58±0.15	23.17±0.35	39.43±0.78	13.33±0.45	79.08±1.31
SPR1	12.30±0.08	27.61±1.01	3.67±0.09	11.61±0.19	23.25±0.40	42.19±0.97	7.02±0.57	84.15±0.85
SPR2	11.99±0.14	17.87±0.80	3.17±0.07	9.75±0.20	26.26±0.47	47.39±0.95	13.28±0.53	11.99±0.14
Wairarapa								
SUM	10.26±0.13	21.10±2.68	2.39±0.11	9.80±0.44	25.80±2.13	49.81±4.13	7.90±0.32	69.38±3.91
AUT	11.34±0.19	19.30±2.66	3.59±0.13	10.63±0.52	25.52±1.38	43.44±3.69	12.98±0.74	76.80±2.83
WIN	11.59±0.17	23.57±1.11	3.41±0.19	11.12±0.22	23.42±1.09	39.79±2.59	12.26±1.06	77.60±3.72
SPR1	12.37±0.08	27.03±1.40	3.76±0.13	11.82±0.25	22.09±0.71	39.17±1.53	10.25±0.31	85.96±1.99
SPR2	12.44±0.14	17.87±1.30	3.34±0.04	9.34±0.37	24.44±0.70	41.94±1.15	16.39±0.36	83.64±1.15
Canterbury								
SUM	10.06±0.17	21.11±1.14	2.33±0.20	9.80±0.25	27.04±0.74	52.73±1.41	4.80±0.48	69.38±1.31
AUT	10.88±0.33	22.24±1.18	3.46±0.13	11.34±0.18	26.22±0.77	44.81±1.41	10.14±0.63	74.84±2.18
WIN	10.62±0.23	22.68±1.06	3.33±0.14	11.68±0.26	25.77±0.68	44.36±1.53	8.54±0.49	71.67±1.65
SPR1	12.50±0.10	29.52±0.43	3.90±0.07	12.63±0.19	22.68±0.23	38.70±0.76	8.53±0.38	84.80±0.83
SPR2	12.28±0.08	21.97±0.60	3.30±0.06	10.55±0.13	25.32±0.30	44.39±0.81	11.75±0.39	81.60±0.54
Southland								
SUM	11.77±0.38	23.04±1.48	2.62±0.29	8.93±0.56	21.77±0.98	44.38±2.16	11.87±1.85	81.97±2.03
AUT	11.82±0.17	24.04±0.93	3.63±0.16	11.59±0.25	23.57±0.90	39.29±1.45	12.19±0.49	82.50±1.81
WIN	9.69±0.58	19.17±1.46	2.68±0.20	10.74±0.22	27.27±1.92	50.46±4.14	8.45±1.09	65.08±4.28
SPR1	11.70±0.37	25.53±1.38	3.64±0.20	11.85±0.70	22.06±1.03	38.16±3.00	10.29±0.73	79.55±3.31
SPR2	12.48±0.01	20.74±0.68	2.92±0.11	8.09±0.48	21.81±0.71	41.90±0.87	15.37±1.20	84.75±0.28

6.3 Questionnaire - Equine Pasture Management 2008-2009

STUD	**DATE**

STUDMASTER:

Is the pasture management the sole responsibility of the Stud Master or does a farm/pasture manager provide input into pasture management?

FARM/PASTURE Manager:

Total area of land (Ha) used for Stud operation	
Proportion (% of total area) leased, (if any)	

Pasture Renewal Programme	**Comment/s**
Renewal schedule (yes/no)	
Renewal frequency	
Proportion of Farm in each renewal cycle	
Reason/s for new pasture	
Seed direct drilled	
New pasture sowed after crop	

Typical Current Pasture Composition	*As % of total pasture (approximate)*
Ryegrass	
Other grasses	
Clover	
Weed	
Pasture Herbs	

Does the stud use any of the following professional services	*Please tick*
Fertiliser Representatives	
Pasture/ Seed Companies	
Agronomist	
Nutritionist	
Farm Consultant	

CURRENT Proportion of HIGH versus LOW Endophyte Ryegrass:

HIGH Endophyte	
LOW Endophyte	

Pasture species included in new seed mix for pasture renewal

GRASSES	***Please tick***	Approx % of total
Perennial Ryegrass		
Hybrid Ryegrass		
Italian Ryegrass		
Tall Fescue		
Grazing brome		
Cocksfoot		
Phalaris		
Prairie Grass		
Browntop		
Yorkshire fog		
Timothy		
Other		

LEGUMES	***Please tick***	Approx % of total
White Clover		
Red Clover		
Lucerne		
PASTURE HERBS		
Plantain		
Dandelion		
Chicory		
Yarrow		

Proportion of NEW Ryegrass seed LOW or HIGH endophyte

LOW	HIGH

	< 12 months	**1– 2 years**	**> 2 years**	**Other**
Soil Analysis				
Fertiliser Application				

FERTILISER	***Please tick***	**Application Rate**	**Time of year applied**
Super phosphate			
Superphosphate combination; e.g. NPK			
Urea			
Lime			
Di-Calcic			
Seaweed			
Other (please specify)			
Liquid or Solid Application			

Pasture Management Practices: *(please tick those that apply)*

	Summer	Autumn	Winter	Spring
Harrowing				
Topping/Mowing				
Cross grazing with other stock				
Weed Spraying				
Pasture Rotation				
Pasture Spelling				

Other Grazing stock used *(please tick)*

	Summer	Autumn	Winter	Spring
Sheep				
Cattle				
Goats				

How are other grazing stock utilised?

	Please tick
Grazing simultaneously with horses	
After the horses have been moved out	
Before the horses are put in to graze	

Typical Horse Stocking Rates

	Mares	Mares and Foals	Weanlings	Yearlings
Typical Paddock Size				
Numbers each group				
Reason, e.g. Ease of handling Paddock Size Pasture cover				

Does Sward Height Influence the length of time in any given paddock? Y/N	

Irrigation

	Y/N
Does the stud use irrigation at any stage during the year	

Rank the following, (in order of importance) the following pasture/nutrition related diseases:

Rank: 1 most important, use = if two have same importance or N/A if not considered important

Mineral imbalances	
Joint/limb deformities	
Bone diseases (DOD, OCD etc)	
Ryegrass Staggers	
Other, please specify	

Ryegrass Staggers	***Comment/s***
Observed or not observed	
If observed, approx percentage of horses affected in last season.	

When supplementary feed is used, eg hardfeed/concentrate etc is it because of the difficulty of knowing if the horse is consuming sufficient nutrition from pasture to meet its requirements?

Disagree	
Don't Know	
Agree	

Do you believe that Ryegrass staggers is a problem facing the breeding industry in NZ?

Disagree	
Don't Know	
Agree	

Do you believe that DOD, OCD is a problem for the breeding industry in NZ?

Disagree	
Don't Know	
Agree	

Do you believe that producing a yearling for the sales of desirable weight and height is the main aim of the breeding industry in NZ?

Disagree	
Don't Know	
Agree	

Breeding Stock numbers; (present on total land area available for use by stud operation):

Total number of stallions standing:

Numbers of Mares, Foals and Yearlings (in one year)

	Mares	Foals - Weanlings	Yearlings
Spring			
Summer			
Autumn			
Winter			

Are any of the mares moved away from the 'Main Stud Operation' for an extended period at anytime during the year, (e.g., to return in time for foaling)? If so, approximately how many and where are they moved to?

Supplementary Feeding*, (in addition to ad-lib pasture):* The information will be used as a guide to the level of supplementary feeding provided in addition to pasture across a year. Choose *either* the 'per group' column or the 'per horse', whichever is easier given your operation.

	SEASON	**FEED TYPE**	***Approx* amount, per group/day *OR***	***Approx* amount, per horse/day**
MARES	Spring	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Summer	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Autumn	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Winter	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
FOALS	Summer – with dam	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Autumn – at weaning	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Winter – first winter	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
YEARLINGS	Spring	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Summer	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Autumn	Concentrate/Grain		
		Haylage/Baleage		
		Hay		
	Winter	Concentrate/Grain		
		Haylage/Baleage		
		Hay		

6.4 STOCKING DENSITY RAW DATA

STUD FARM	land size Ha	Mare/Ha (Spring/summer)	Foal/Ha (spring/summer)	Mixed-age/Ha (spring/summer)	Mare/Ha (winter)	Weanling/Ha (winter)	Mixed-age/Ha (winter)
1	100	2	1.4	0.4	0.8	0.7	0.3
2	300	1.7	0.7	0.3	0.4	0.3	0.1
3	186	0.4	0.2	0.2	0.4	0.2	0.1
4	51	2.2	1.5	1.1	1.8	1.5	0.6
5	104	0.7	0.6	0.2	0.4	0.2	0.05
6	130	0.8	0.3	0.2	0.6	0.3	0.2
7	240	0.8	0.6	0.3	0.5	0.3	0.1
8	120	1	0.9	0.4	0.6	0.4	0.2
9	130	1.9	1.2	0.1	0.8	0.2	0.1
10	115	1	1	0.1	0.6	0.5	0.1
11	235	2.6	2.1	0.1	0.8	0.1	0.1
12	40	3.2	1.3	0.4	1.2	0.8	0.1
13	240	0.8	0.8	0.1	0.4	0.2	0.1
14	130	1.5	0.4	0.4	0.8	0.5	0.1
15	202	0.4	0.1	0.1	0.4	0.1	0.01
16	165	0.4	0.4	0.4	0.4	0.3	0.2
17	120	1.2	1.2	0.3	0.4	0.6	0.2
18	144	1.3	0.7	0.5	0.6	0.5	0.1
19	223	1.1	1.1	0.3	0.5	0.4	0.1
20	160	0.7	0.5	0.4	0.5	0.4	0.2
21	324	1.5	0.9	0.2	0.8	0.4	0.05
22	486	1.2	0.6	0.2	0.4	0.2	0.05
23	130	1.4	0.6	0.3	0.8	0.4	0.6
24	86	1.6	0.5	0.5	0.8	0.6	0.1
25	60	0.5	0.25	0.3	0.5	0.2	0.2
26	567	0.9	0.5	0.3	0.4	0.3	0.1

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