THE INFLUENCE OF MINERAL NUTRITION OF PASTURE GRASSES ON THE GRAZING PREFERENCE BY SHEEP.

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This investigation on grazing preference of sheep used two experimental methods; rate of intake by penned sheep and field grazing observations.

Ewe hoggets were fed fresh cut leaf to examine the rate of intake of six pasture grasses of differing nutrient status. Sheep exhibited no specific preference in rate of intake trial one during autumn and it was concluded that sheep appetite may have influenced the result. Phalaris leaf in rate of intake trial two during autumn was consumed at the greatest rate (43.2g WM/min - 8.7g DM/min) with timothy leaf being least preferred (17.4g WM/min - 4.8g DM/min). Both on a wet and dry matter basis cocksfoot leaf in rate of intake trial three during spring increased when nitrogen levels increased from 2.83 to 5.22% N. In contrast Yatsyn ryegrass showed no relationship (2.16 to 4.48% N) on a wet matter basis, but on a dry matter basis rate of intake decreased with increasing nitrogen levels (11.02 - 6.36g DM/min). Ryegrass endophyte (*Acremonium lollii*) hyphae concentrations were doubled at high nitrogen levels and this may have caused the reduction in intake.

Field grazing trials measured the rate of decline in height of six pasture species of differing nutrient status. Phalaris was the preferred species in field trial one during autumn, being reduced in height at a fast rate and to a low residual height (1.45cm). With field trial two during autumn there appeared to be more than one preferred species as tall fescue, timothy/Marsden ryegrass mixture and Marsden ryegrass over the first two days were reduced at similar rates to phalaris. In field trial three during spring there was no preferred species. After nitrogen fertilisation at equivalent rates to a urine patch, sheep in field trial one showed no strong preference for fertilised herbage and in field trial two there was an initial preference as leaf heights were rapidly reduced in the first day (6-13cm), but there after, rate of decline was similar between treatments. Phalaris in field trial three after nitrogen fertilisation was clearly preferred and reduced in height at a fast rate with cocksfoot also being reduced severely over the first two days. Therefore it was concluded that high nutrient herbage levels will not always overcome differences in preferences between species. Also fertilisation can mask preference of less preferred species such as cocksfoot. It was also suggested that presence of legumes in plots may have reduced the ability of sheep to discriminate between species and treatments in field trials one and three.

Rate of intake trials did not in all cases correlate well with preference observed in the field such as in rate of intake trials two and three.

Keywords: Cocksfoot, ewe hoggets, field grazing trial, grazing preference, Marsden, nitrogen fertilisation, phalaris, rate of intake, ryegrass endophyte, sheep, tall fescue, timothy, timothy/Marsden ryegrass mixture, Yatsyn ryegrass.

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CHAPTER ONE
INTRODUCTION

The use of pasture by grazing animals is the basis of New Zealand pastoral agriculture. Pastures in New Zealand are predominantly the grass/legume type such as ryegrass/white clover. These pastures are preferred by farmers for their fast establishment, relatively good persistence, and productivity on many soil types and climatic conditions. Other advantages stem from the ability of the legume, white clover to fix nitrogen and its high nutritive value.

Most of the perennial ryegrass (*Lolium perenne L.*) grown in New Zealand contains *Lolium endophyte* (*Acremonium Lollii*) which gives resistance to Argentine stem weevil but has the disadvantage of causing ryegrass staggers. Other disadvantages of ryegrass include low summer production in drier regions, susceptibility to grass grub and the fact that sheep tend to discriminate against ryegrass containing endophyte.

Dissatisfaction with ryegrass has resulted in increasing use of alternative grass species over the last decade. Special purpose summer growing grasses such as "Grassland Roa" tall fescue which once established gives annual yields similar to perennial ryegrass and species such as "Grasslands Matua" prairie grass the ability to out yield perennial ryegrass in most seasons. Others include drought tolerant species such as "Grassland Wana" cocksfoot or more recently "Grasslands Gala" grazing brome and highly palatable species such as "Grasslands Kahu" timothy.

Previously substantial work has been carried out in areas of grazing preference such as the following:

* The importance of the senses in diet selection (Kruegar and Laycock, 1971; Arnold, 1966a, 1981).
* The difference between animal species in their grazing preferences (Van Dyne and Heady, 1965; Hunt and Hay, 1990).
* The influence of sward characteristics (L'Huillier *et. al.*, 1984; Black and Kenny, 1984).
* The influence of plant species (Hughes, 1975; Johnson, 1992).
* The influence of external factors such as nutritional status or soil fertility (Stapledon, 1934; Keogh, 1973, 1986).

It is surprising that little research has been conducted into the dietary preferences of domestic animals for particular plant species in relation to the nutritional status or soil fertility - information fundamental to any assessment of the value of pasture in animals nutrition.

Knowledge of grazing preference of animals will mean great improvements in the following:-

1. Animal Production.

Animal productivity and voluntary food intake relationships are will recognized (Allden and Whittaker, 1970) and restricted nutrient intake is the major factor limiting the production of grazing animals (Hodgson, 1981). Therefore animal productivity may be enhanced through greater intake associated with the use of preferred pasture species provided they are of high nutritional value. The low live-weight gains of sheep grazing endophyte infected ryegrass (Fletcher, 1986), and the decreased voluntary intake of steers on endophyte infected tall fescue

(Goetsch *et. al.*, 1987), both indicated that increased intakes and production would be achieved on more preferred pasture species. Brown (1990) discussed the possibility of improved live weight gains in sheep grazing systems by the use of preferred species such as chicory. By using preferred pasture species farmers should be able to grow animals closer to their genetic potential and inturn increase their profitability.

2. Pasture Composition.

Pasture composition will depend on the species establishment ability, grazing system used and species preference, and weeds present as well as their palatability. Faster establishing ryegrass can smother slower establishing tall fescue. Also preferred species can soon be eaten out of the pasture leaving less preferred species to dominate. This occurs especially in set stocked situations where animals graze regrowth continually. Therefore, it is important to have plant species that require set stocking together and plant species that require rotational grazing together. Thus care must be taken when deciding what species to use and relative quantities of species to sow in pasture mixtures as well as grazing system to be used. For instance, farmers should be wary of the vigour of ryegrass seedlings when sowing mixtures and keep ryegrass seeding rates low (Lucas and Fraser, 1989). Many farmers also have perennial weed infestations in their permanent pastures. Understanding the grazing preference of stock for such weed species may enable control strategies such as grazing different classes of stock. This would be a cheap alternative compared with the costly control by herbicides.

3. Utilisation and Stability or Persistence of Pastures.

Pasture species preference by sheep have in the past been considered important to the full utilisation and stability of pastures. Utilisation can be improved through using highly palatable species and to obtain full production and stability of pastures, the herbage must be relished by the animals. Selective grazing tends to hamper the more palatable species. To avoid this effect Jones (1928) cited by Ivins (1955) advocated controlled grazing to allow the more palatable plants to recover and assert themselves over their less palatable associates. Ivins (1955) also stated that to a large extent palatability of a sward can be enhanced by maintaining an adequate proportion of clover and by application of nitrogenous fertilizers, lime or phosphate under some conditions.

This investigation is aimed to evaluate the grazing preference by sheep for some commonly grown pasture species and the effect of soil fertility or nutrient status has on preference with a specific consideration of urine patches. The investigation took place using two experimental areas; Plant Science Department Iversen Field Research Area at Lincoln University, and Lincoln Universities Dry Land Farm Ashley Dene. This dissertation is an extension of the work of Edwards (1990) and Johnson (1992).

CHAPTER TWO
REVIEW OF LITERATURE

DIET SELECTION BY GRAZING ANIMALS.

2.0 INTRODUCTION.

Hodgson (1979) defined diet selection by grazing animals as the removal of some sward component(s) - plants or plant parts - rather than others. It is a function of preference (defined as the discrimination between swards or sward components) modified by the opportunity for selection, which is determined by the relative proportions of the preferred components in the sward and their distribution within the canopy.

This review covers the main factors that influence grazing preference.

2.1 PHYSIOLOGICAL FACTORS IN SELECTION.

2.1.1 The Role of Senses.

Animal preferences for foods are stimulated by the senses of sight, smell, taste, touch, and perhaps hearing in special instances (Heady, 1975). Therefore grazing animals use the senses of sight, touch in the lips and mouth, taste and smell in selection of their diet. Sight or visual sense is used primarily to orient the grazing animal to other sheep and to its environment (Arnold, 1981). Thus sheep recognise conspicuous food plants by sight but do not use sight to help them-graze selectively. Arnold (1966a) found that the diets of blinkered sheep were similar to those of control sheep under a wide range of conditions and therefore the visual sense helps sheep to recognise a familiar plant but it appears of little use for differentiating between plants with similar morphological characteristics, or between different plant parts.

According to Davies (1925) harshness and hairiness in plants encourages rejection while succulence encourages acceptance. Recognition of this variability by neutral pressure receptors leads to selection of plants that give favourable stimuli (Arnold, 1966a). Consequently sheep retaining a tactile sense ate a less-steamy diet, higher in carbohydrates than surgically non-tactile sheep (Krueger and Laycock, 1971). Arnold (1966b) also hypothesized that this selection for low density green plant material, caused sheep to unconsciously select herbage of high nutritional quality and digestibility.

According to Krueger and Laycock (1971), taste is the most important sense in diet selection. Bell (1959) considered that it had protective as well as nutritive significance. Taste response was stated by Bell and Kitchell (1966) to be the reaction of chemoreceptors associated with the papillae of the tongue to threshold concentrations of the four primary taste modalities; sweet, sour, salty, and bitter. Plice (1951) demonstrated that the sweet taste was the dominant preferred taste while the bitter taste causes the most adverse responses (Goatcher and Church, 1970).

Edwards (1990) quoted that there were few reported studies relating the chemical composition of plants to their olfactory responses.

2.1.2 The Influence of the Age and Physiological Condition of Sheep.

Food preference of animals is influenced by their age. For instance, Jones (1952) observed that young sheep generally ate only the more succulent parts of plants compared to adult sheep. As well Arnold (1981) reported that at five months of age sheep had a diet that was higher in digestibility and in nitrogen content and lower in fibre content than that of older sheep. However other authors have found only small unimportant differences in diet selection with differing ages.

On the other hand, changes in physiological condition such as pregnancy and lactation do not themselves appear to affect the diet of sheep. The extent which diet selection is altered by the metabolic state of the animal has not been studied in any detail. The only evidence on the effect of metabolic state is Arnold *et. al.* (1964) cited by Milne (1991). Here they found development of hunger by the penning of animals for periods up to twelve hours without food,which can be considered as an alteration in metabolic state, was found to alter the composition of the diet of sheep.

However preference for a particular plant may not be due to an animal selecting for some attractive characteristic, but rather to selection against the obnoxious characteristic of other plant parts (Arnold, 1981).

2.2 ANIMAL FACTORS IN SELECTION.

2.2.1 Differences between Species.

Domestic livestock differ between genera in their preference for certain types of herbage. Linnaeus (quoted by Tribe and Gordon, 1950) offered 618 different plants both singly and in mixtures to sheep, cattle, goats, horses, and pigs. He discovered that in many cases, while animals of one or two different genera would accept a particular plant, those of other genera would reject it.

Hunt and Hay (1990) reported that deer show preference for low oestrogen red clover, calves prefer cocksfoot while horses prefer prairie grass. This was supported by Hunt and Hay (198 who found deer showed a high preference for legumes over grasses. They found low oestrogen and *Lotus corniculatus* to the most preferred by all classes of deer. Selection for whit clover by deer was also reported by Bootsma *et. al.* (1990). Sheep may graze white clover in proportion to that on offer while goats reject white clover (Clark *et. al.*, 1982).

Heady (1964) and Van Dyne and Heady (1965) generally found tha sheep, like goats, are more selective in their grazing than cattle and choose acceptable plant parts rather than whole plants. Sheep eat grass freely, particularly if it is young a succulent. They are more likely to reject mature grass than cattle. Sheep prefer to browse more than cattle but less than goats. Sheep have a strong preference for herbs and for a di containing a wide variety of species.

Possibly the most outstanding variable involved is body size o the ruminant (Milne, 1991). Absolute feed requirements, the inability of fine-grained food selection and retention time in the gut all increase with body-weight (Gordon and Illius, 1988 cited by Milne, 1991). Larger animals ingest food of potentially lower nutritive value (Hodgson, 1981). Rumen size relative to body size also differs between animal species and this is in part responsible for changes in indigestive capability for fibrous grasses, trees and shrubs (Demment and Van Soest, 1985 cited by Milne, 1991).

Generally it is known that ruminants with a large body size wi digest fibrous foods better because of larger rumens and longe retention times. Because of this small ruminants have to rely on foraging strategies which allow them to ingest a diet with high cell content. Therefore foraging strategy, diet selectic and digestive ability are linked.

Differences in anatomy of mouthparts may reflect the diet differences between species (Van Dyne *et. al.*, 1980). For example, cattle have no upper incisors and use the tongue to aid prehension, while sheep have a cleft upper lip and goats have a mobile upper lip and prehensile tongue. But the goats ability to stand on hind legs will also aid in diet selection.Therefore these differences in anatomy represent differences in selection capabilities rather than differences in selection drive. In some cases differences in diet selection may reflect species size or size differences in the physical ability of animals to reach some sward components (Hodgson, 1982).

2.2.2 Differences within Species.

Large differences exist between individuals of one genus. Arnold (1964a) reported that the proportion of grass in the total intake of individual sheep can vary between 10% and 80%. However Edwards (1990) results did not agree with this as he found only small variations between sheep in the eating rate of six different fresh, cut feeds. As well Van Dyne and Heady (1965) found between sheep variation in the botanical composition of diet to be greater than within-day or between-day variation. Thus, although a population of sheep may indicate an average rating of preference among plants on offer, individual choice may vary widely. Therefore, a reasonable number of animals is needed in preference studies (Edwards, 1990). However if differences do occur within species it may be due to factors such as breed, age and physiological differences.

2.2.3 Influence of Previous Experience on Selection.

Experience may also be important in influencing the foraging behaviour of sheep, cattle, and goats (Arnold,1970 cited by

Milne, 1991). When Robards (1965) tested the acceptability to sheep of cultivars of phalaris he found that one cultivar became more acceptable as the period of grazing increased, irrespective of changes in grazing pressure. The initial rejection of this variety by sheep may be due to unfamiliarity with the plant as forage. Other work reported a similar reaction of sheep to sweet vernal, Yorkshire fog and the sweet clovers (Jones, 1952). On the other hand Arnold (1964a) stated that differences between sheep in how soon they accepted unpopular species quickly disappeared, however at least one month elapsed before *Stipa hyalina* and *Eragrostis curvula* were eaten. Arnold concluded that previous grazing experience had a strong influence on the preference ranking of species of plants. According to Tribe (1950) social facilitation may encourage animals to graze particular species of plants by the example of other animals in the flock.

2.3 GRAZING BEHAVIOUR.

The grazing intake of an animal is the result of the size of bite, number of bites per unit time and the amount of time an animal spends grazing (Allden and Whittaker, 1970). It is often expressed by the following formula:

$$I = IB * RB * GT$$

where **I** = **Intake.**
IB = **Intake per bite.**
RB = **Rate of biting.**
GT = **Grazing time.**

Sward characteristics (i.e. green leaf distribution and dead material content) would influence intake per bite and rate of biting with the animal modifying its response by altering grazing time and perhaps rate of biting. Of these behavioural parameters intake per bite appears most sensitive (Hodgson, 1981), while grazing time and rate of biting are not so sensitive.

2.4 GRAZING INTENSITY.

Grazing pressure on a block increases if the stocking rate remains constant, but the pasture consumption exceeds the rate of pasture production. Therefore the choice of plants and/or plant available to the animal decreases with this increased pressure. Also as preferred plants become scarce, previously unacceptable plants or parts of plants get eaten. Consequently, there tends to be a successional change in the characteristics of the diet (Hughes, 1975).

As well Cook *et. al.* (1953) demonstrated that as the opportunity for selection between plants decreases there may be an increase in the proportion of fibre and lignin in the forage intake. Arnold *et. al.* (1966b) showed that in the long term protein intake could increase as pasture growth responded to more intensive use but initially fell to the increased grazing pressure.

2.5 EXTERNAL FACTORS.

2.5.1 Diurnal Variations.

Major grazing periods began near dawn and again in late afternoon (Arnold, 1962). As the days get shorter, the breaks between grazing also get shorter (Arnold, 1981).

There are also reports of temperature influencing grazing behaviour. Arnold (1981) showed that when daily maximum temperatures are <15 ^{0}C and little night grazing is done, but when they are high, >25 ^{0}C, night grazing varies form 0 to 70% of total grazing time. Also Arnold (1964b) reported that as daily grazing time increased selectivity also increased.

Diet selection by sheep and cattle alters during the day (Arnold, 1981). Variation will be more pronounced on rangelands or high country areas where diets alter with location change. Ohioha *et. al.* (1970), quoted in Arnold (1981) found that diet of cattle to contain more grass than herbs in the morning and the opposite in the evening. This suggests that in the morning period when the animals desire to eat is stronger, grass will be consumed because it is more accessible.

2.5.2 Soil Physical and Chemical Status.

Palatability of plants varies with soil fertility. For example, Bermuda grass on fertile soil or with liberal amounts of soil amendments is relished by most classes of livestock. The same grass on a poor soil is very low in palatability (Harlan, 1956). A similar phenomenon has been found by other researchers, such as Tomanek *et. al.* (1988), quoted in Hughes (1975). They noted that a single species of plant could vary in attractiveness to stock when growing on different sites.

Plant acceptability may also be affected by soil-moisture status. Plants growing on soils at field capacity are likely to be more succulent, and accessible due to their upright or erect habit (Hughes, 1975). However under conditions of high soil moisture coupled with poor drainage, acid soils, and lack of available soil minerals, acceptability of plants can be reduced (Jones, 1952) quoted by Hughes (1975).

Also water content of pasture has been shown to influence preference. Kenny *et. al.* (1984) conducted limited preference tests with sheep fed Kikuyu grass containing either 90 or 15 per cent DM and found that water content of this forage had little effect on preference. However more extensive studies by Kenny *et. al.* (1987) cited by Mackle (1992) using barley grass predominant swards and forage covering a wide range of DM contents showed that water content of a forage can have a major effect on sheep preference. For example comparisons with grasses containing either 11 or 36 per cent DM showed sheep to strongly select for the forage with higher DM content when other characteristics are identical. Literature is lacking in this area and it is clear that more studies are required across a greater range of species and forage types.

Animals also prefer plants which have been fertilised with phosphorus. Plice (1951) considered that this was due to higher soluble carbohydrate levels in such plants. Ozanne and Howes (1971) also came to the same conclusion that plants high in phosphorus content were preferred due to the carbohydrate levels but as well, that these plants had the lowest content of the usually-unpalatable free phenols.

Stapledon (1934) stated that application of lime and basic slag to hill areas deficient in calcium and phosphorus attracted sheep to graze. This attraction was enhanced when nitrogen was also added but it was noted that the animal response was not necessarily the same when nitrogen was applied to more fertile soil.

Under continuous stocking, livestock select urine-patch in preference to inter-urine patch and dung patch herbage (Keogh, 1986). This was expressed as a higher intensity and greater frequency of defoliation of herbage at urine patches (Keogh, 1973). Under rotational grazing livestock remove a greater proportion of material present at urine patches than at inter-excreta sites (Keogh, 1973). However if urine scorches or kills the grass within the excreted area, deterioration in botanical composition of the sward may occur as well as selective grazing (Richard and Wolton, 1975). Keogh (1984) showed most recent urine-patches to be defoliated sooner and to a greater extent than older ones.

Joblin and Pritchard (1983) stated as well that animals selectively graze urine patches and that such a preference would markedly lower selenium intake inducing selenium deficiency since urine patches contain minimum selenium concentrations. Also Keogh (1984) found concentrations of the ryegrass endophyte Acremonium loliae were higher in urine patches than at inter-excreta sites thus controlling defoliation at these sites would be beneficial in prevention of ryegrass staggers. However, white clover incidence also influences feeding behaviour. Keogh (1973) showed inter-excreta areas containing white clover are grazed in preference to similar ryegrass dominant areas devoid of white clover. And as well Keogh (1986) showed that ryegrass present in areas containing white clover will be also grazed harder than ryegrass at either urine-patches or inter-excreta sites. Edwards (1990) showed urine patches to be defoliated quicker and more pasture mass to be removed than non-urine patches. He concluded that even though the urine patches contained a higher proportion of endophyte which seems contrary to earlier findings with respect to avoidance of +E ryegrass. Other overriding factors, such as chemical status may be influencing. Johnson (1992) reported sheep grazing preferences for high nitrogen pasture which was believed to represent the approximate concentration of a urine patch (i.e. 300 Kg/ha).

Animals particularly cattle, normally avoid plants soiled with faeces. Tribe and Gordon (1950) considered that it is the smell of faeces rather than any intrinsic property of the herbage which causes cattle to avoid areas of soiled vegetation. Plice (1951) tried to find why stock avoided grazing plants growing on high nitrogen dung enriched areas. He found these areas to be high in protein, fat, vitamins, calcium, potassium and iron, but low in silica, aluminium, phosphorus, chloride, sugars and tannin.

Forbes and Hodgson (1985) showed that cattle are more sensitive than sheep to the presence of their own dung but sheep rejected herbage around cattle and sheep dung equally. This indicates that under mixed grazing a smaller proportion of the total herbage surrounding dung pats would be rejected by sheep than by cattle, giving the sheep a competitive advantage. However, the ungrazed herbage around dung becomes mature and unpalatable, and rejection is then largely due to this factor rather than to the proximity to dung (Norman and Green, 1968) quoted by Watkin and Clements (1978).

Marsh and Campling (1970) stated similar conclusions but commented that if stocking rates increase, cattle tend to graze closer to dung-pats, thus reducing the amount of rejected herbage. As well Nolan *et. al.* (1988) showed adding sheep with steers (i.e. mixed grazing) prevented herbage around steer dung patches from growing tall and rank and thus rendering an extra 15% of the area available for steer grazing.

2.5.3 Climate.

Climatic stress can effect the morphology of plants, their nutritive value, moisture content, and relative acceptability to grazing animals (Hughes, 1975). High summer temperatures accentuate the plant characteristics of cuticle and epidermal thickening, hairiness and spine-form which is an adaption associated with avoidance of transpiration stress. The presences of these features in plants tends to decrease their acceptability to animals (Heady, 1964). For instance, plants with coarser leaves generally seemed more acceptable when wet with dew or rain than when dry.

2.5.4 Plant Availability.

Arnold (1964) defined "availability" as relating to frequency of occurrence, relative yield and accessibility, as well the nature of the surrounding plant material and that this will influence acceptability to animals. Edwards (1990) reported heights of white clover post grazing differed with species of grass. For example, white clover was grazed lower in association with tall fescue compared with ryegrass.

2.5.5 Time of Season.

With most plants, acceptability can be equated with the proportion of fibre, particularly lignified fibre, in the forage. As plants approach maturity the rate of increase in the proportion of fibre in their aerial tissue varies between species. This leads to seasonal changes in the relative preference of herbivores (Hughes, 1975). For example, Davies (1964) cited by Hughes (1975) found only small differences in preference between grasses and clover in a Southern Australian sward in mid spring (October) but by early summer (December) grass was the preferred forage. In turn, as the grass dried off in late summer (February) clover plants were sought.

2.6 DIET SELECTION AND DIGESTIBILITY.

Although there have been may reports describing the diet selected by animals using *in vitro* digestibility, most provide little basis for understanding why particular plant components were selected. Digestibility is likely to be correlated with other factors that influence diet selection.

Plants of high digestibility are likely to have characteristics such as a high proportion of non-structural carbohydrates, proteins, and organic acids (Van Soest, 1968) quoted by Hughes

(1975). Such characteristics make them more acceptable to sheep than plants of low digestibility.

The proportion of lignin and structural polysaccharides increases with age, and is more pronounced in later formed tissues such as culms and stems (Hughes, 1975). And according to Heady (1964) this increase parallels decreasing acceptability to grazing animals.

2.7 SWARD CHARACTERISTICS AND PLANT SPECIES.

The spatial arrangement of herbage in three dimensions gives herbivores of wide range of opportunities for diet selection. A typical mixed sward canopy in a vegetative stage of growth consists of an upper horizon consisting primarily of grass leaf lamina and a lower horizon consisting of leaf sheaths (aggregated into pseudostem) and dead tissue legumes, herbs and in mature swards true stems, are distributed throughout the canopy (Hodgson, 1979).

Grazing animals can also select within the vertical plane of the sward between different plant parts of the same species of different species. An example of this can be found in grass-clover swards, which, although they appear relatively homogenous in the horizontal plane, have considerable variation in grass leaf and stem and clover leaf and petiole in the vertical plane.

Distinguishing independent effects of variations in grass sward characteristics such as herbage mass, sward height, pseudostem height, density, and green leaf distribution on diet selection is difficult. Observations of grass sward characteristics probably do not provide an adequate description of vegetation as perceived by the grazing animal.

The relative proportions of the different plant species of components and their distribution in space will modify selection. The grazing process has been described as been modified into a two phase concept involving "site selection" and "bite selection" (Milne *et. al.*, 1979 and Milne, 1991).

2.7.1 Site Selection.

Initially grazing site will be determined by the physical environment-slope, aspect, topography, distance to water, climate, animal tracks, shade availability, and subdivision (Arnold, 1981), through effects on the energy expenditure of ruminants (Milne, 1991).

In Australia it is recognised that sheep paddocks on rangelands are most heavily utilised in the areas from which the prevailing winds come from (Arnold, 1981). Arnold (1981) also reports variations in intensity of sheep grazing with elevation and rainfall in the mountains of North Wales. Site selection is also influenced by more local factors. For example the differences in stages of growth of different plant communities (Arnold,1981) and patchy distribution of dung and urine. Hodgson, (1982) commented that the way these factors interact has not been fully understood yet.

However it has been argued form an optimal foraging point of view that site selection should be based on choosing those patches of plant material which produced the highest nutrient intake rates for minimum energy expenditure (Milne, 1991). This has been tested in an experiment conducted by D. Clark, A.W. Illius and J. Hodgson (unpublished results) in which height of perennial ryegrass (*Lolium perenne*) sward, which is known to have a positive relationship with nutrient intake rate was varied. The taller swards were generally preferred by all species. Sheep showed the lowest sensitivity to height or intake rate in grazing time with goats being most sensitive.

But goats were found to have a different grazing style from sheep and cattle, taking shallower bites from the sward surface (i.e. indication of a browsing species). This experiment therefore showed that differences in intake rate of material, which had basically the same nutrient density, were important in determining site preference.

However, what cues are used is one question one might ask in determining site selection. Also previous experience, but both of these evidence is variable so their importance is not known for sure. Our understanding of how site selection operates is thus limited.

2.7.1 Bite Selection.

The bite dimensions of interest are depth and area from which volume may be calculated. Bite selection is the choice of individual bites of herbage from the vegetation at a chosen site. The opportunity for bite selection reflects the heterogenous nature of natural pastures and the distribution of plant components in vertical and horizontal planes. Canopy structure may also be important. The open structure of annual tussock grasslands for example allows easy access to all levels of the sward (Hodgson and Grant, 1980) compared with short closed canopies.

Selection will depend on both preference contrasts between alternative components of swards as well as their distribution within the canopy (Hodgson, 1982). Sheep may gaze relatively indiscriminantly at the surface of intensively managed *Lolium perenne/Trifolium repens* swards (Milne *et. al.*, 1982), but consideration must be given to the fact that this is in Great Britain, where pastures differ (i.e. tiller number). However, selection for *Trifolium repens* growing close to the base of *Agrostis/Festuca* swards can be more extreme (Hodgson and Grant, 1980)

Sheep also readily graze into the leafy horizon of the vegetative sward and are reluctant to graze into lower horizons containing pseudostem plus a higher proportion of dead material (Barthram and Grant, 1984). The depth to the leaf horizon appears to set an effective limit to the depth of bite. Barthram and Grant (1984) showed the depth to be around 20-30 mm deep, but swards with deeper leaf horizons there is a roughly proportional relationship between sward surface height and bite depth (Milne *et. al.*, 1982).

Trials carried out by L'Huillier *et. al.* (1984) also found that green leaf is preferred over pseudostem and dead material and was the major determinant of the horizon grazed. Pseudostem content of the diet was low and rejected by the grazing animal.

L'Huillier *et. al.* (1984) also found that white clover was harvested by sheep in proportion to its presence in all horizons of the sward indicating no diet selection, which implies that vertical distribution of major dietary components influences white clover consumption rather than animal preference. Milne *et. al.* (1982) demonstrated that if one simply looks at the relationship between the proportion of clover in the sward and the proportion of clover in the diet, it is obvious that selection has occurred for clover. However if we take into account the relationship between bite depth and sward surface height and examine the actual horizon grazed by sheep, evidence appears to be less for selection, with the sward surface height explaining most of the variation in proportion of clover in the diet. Also further examination of the findings showed at low levels of clover in the grazed horizon, there was selection for clover and at high levels of clover in the grazed horizon there was selection against clover. Milne (1991) hypothesised that in foraging circumstances where partial consumption of feeds taking place, animals need to sample food by consumption because other cues of diet selection are either short-lived or inadequate. Others like Bootsma *et. al.* (1990) and Clark *et. al.* (1982) have experienced difficulty in determining pasture species preference unequivocally in mixed swards which is greatly influenced by the relevant proportions of plant species within the different grazing horizons. Overall however there is fairly conclusive evidence that selection in favour of white clover occurs.

Very little work has been performed on the grazing preference of sheep for different pasture species. A study undertaken by Hughes (1975) examined the grazing preference of sheep for twenty five different pasture species on developed and undeveloped tussock grassland at a high country site. Table 1 shows the preference and abundance ranking of selected species on the developed block.

Table 1: Preference and Abundance Ranking over 12 months on the Developed Tussock Grassland block.

Species	Preference	Abundance
Ryegrass	1	12
Cocksfoot	2	7
Browntop	3	1
White clover	5	11
Danthonia	8	9
Red clover	10	3
Fescue tussock	16	5

(Hughes 1975).

Ryegrass was clearly preferred but it was only growing in high fertility sites (i.e. sheep tracks where dung and urine were deposited) and therefore higher in nutritional status. However, fescue tussock growing on lower fertility sites like many other fibrous grasses tended to be avoided due to its low palatability. The ranking of preferred species appeared to be influenced by when growth began in spring, the rate at which maturity and senescence stages of growth were reached, the characteristic and proportion of cell wall constituents at maturity, and the ability of the species to tolerate the level of defoliation to which it was subjected.

Edwards (1990) observed in field trials comparing "Grassland Roa", tall fescue and 'Grasslands Nui" ryegrass, low (-E) high (+E) endophyte, that the proportion of ewes grazing the tall fescue plots compared with the ryegrass plots was significantly higher (Table 2).

Table 2: Proportion of total ewe hoggets grazing each grass treatment over the ten day duration.

Grass	Proportion of total ewe hoggets grazing each grass treatment.
Tall fescue +E ryegrass -E ryegrass	0.38 0.32 0.29
l.s.d (5%)	0.04

(Edwards, 1990).

For the same experiment the grass height was reduced by 74 per cent, 64 percent, and 48 percent respectively for tall fescue, -E ryegrass and +E ryegrass over the grazing duration. These field observations were supported by rate of intake trials with caged animals using fresh cut plant material, Therefore the data clearly show preference for tall fescue over ryegrass and for low endophyte ryegrass over high endophyte ryegrass.

Johnson (1992) examined the preference for a range of common pasture species grown in New Zealand. The field trials showed that "Grasslands Roa" tall fescue and "Grassland Maru" phalaris were preferred over "Grassland Matua" prairie grass, "Grasslands Wana" cocksfoot and Yatsyn perennial ryegrass.

Wana Cocksfoot was not grazed until other species had been grazed to low levels indicating that it was rejected by sheep. These field observations were also supported by rate of intake trials as cocksfoot was consumed at a lower rate than any other species (Table 3).

Table 3: Rate of wet matter (g WM/min) and dry matter (g DM/min) intake of cut fresh herbage (leaf) from rate of intake trials.

Feed type	Rate of Intake	
	Wet Matter (g/min)	Dry Matter (g/min)
Wana	24.2	4.8
Roa	33.6	7.2
Marsden (+E)	30.0	6.9
Timothy	38.2	10.2
Maru	37.2	7.6
Hakari	36.1	8.2
S E M	1.6	0.3
l.s.d (5%)	4.5	0.9

(Johnson, 1992).

Preference for forage is closely related to the rate at which it can be eaten (Kenney *et. al.*, 1984). However at present there are no published relationships which directly relate to intake rates of fresh-matter to preference.

But what is the extent of cues influencing bite selection? Evidence from studies in which one or more of the special senses has been impaired suggests taste is likely to be more important than sight, smell, or touch in influencing bite selection. The evidence agrees with the hypothesis that sampling of vegetation has an important role to play in bite selection.

2.7.3 The influence of Pseudostem on Diet Selection.

The layers containing leaf sheath (pseudostem) inhibit grazing and limit depth of the grazed layer, even when the consequence is a marked reduction in herbage intake. An impenetrable barrier was not present but inhibition was clearly effective (Barthram, 1980). This observation helps explain why herbage intake falls with a reduction in allowance or sward height, even in circumstances where substantial amounts of herbage remain ungrazed. In practical terms, this means that measurement of grazed height may not provide a good index of intake limitations unless they can be related to information about the distribution of pseudostem within the sward canopy.

Grazing inhibition due or pseudostem could be simply difficult to gather into bite catchment of attributed to greater structural strength of stems when compared to leaves (Heady, 1975), proximity of soil surface (Arnold, 1960), higher microbial population in leaf sheaths e.g. *Accemonium lolii* (Keogh, 1986) and increased dead material (Barthram, 1980). Johnson (1992) stated that differences in the height, angle of growth, and rigidity of the pseudostem between pasture species may influence preference.

2.7.4 The influence of Height and Density on Selection.

Generally it has been found that herbage intake increases with height on vegetative swards but the relationship depends on whether height was measured on the extended tiler (Allden and Whittaker, 1970) or on the height of the grazed surface (Hodgson, 1982). Higher intakes have been measured in spring swards compared to summer or autumn which may be due to the more erect spring swards encouraging greater bite depth or simply less dead material and weeds in spring pastures impeding bite depth. But decreased pasture height does not always lead to decreased intake rates. As the sward surface height decreases the bite mass of the animal is decreased. In an attempt to maintain intake rate the animals increase their bite rate and if this did not compensate they extend their grazing time (Allden and Whittaker, 1970; Penning *et. al.*, 1991).

Under field conditions it is difficult to separate the natural correlation that exists between height and density of pastures or to manipulate one factor independently. Thus, confounding results may be obtained. As well plants of differing height often vary in stage of maturity and this influences the rate of consumption (Black and Kenney, 1984). Black and Kenney (1984) overcame the problems by constructing artificial swards of differing height, density and spatial arrangement by placing tillers in holes drilled in wooden boards. It was generally found that sheep preferred long swards to short swards and sparse to dense swards. When sheep were offered artificial swards for periods short enough not to induce satiation, the rate of intake was closely correlated to the intake per prehending bite which decreased with a reduction in sward height and tiller density. However, it was also affected by the spatial arrangement of tillers and thus more closely related to herbage mass per area effectively covered by one bite than herbage mass over the whole area.

The avoidance of tall patches in pastures of variable heights is a common observation. Black and Kenney (1984) however suggested it is unlikely to be avoidance of tall pastures but possibly because of being initially contaminated with faeces and later maturity differences.

2.8 THE INFLUENCE OF POTENTIAL INTAKE RATE ON DIET SELECTION.

Kenney and Black (1984) suggested that potential intake rate was a major determinant of the diet selected by sheep. It was shown that forages that can be eaten fastest were generally preferred over those which were consumed at lower rates but this suggests ease of chewing and swallowing may be the factor influencing this selection. The potential intake rate at which feed can be eaten is determined largely by the physical characteristics of the feed such as ease of fracture, particle size and water content (Colebrook *et. al.*, 1985); but the size of an animals mouth, its degree of satiation and physiological state may also be important (Hodgson, 1982). The potential intake rate by sheep of feeds varies and for some feeds can be altered by changing the physical characteristics such as particle length (Colebrook *et. al.*, 1985; Black and Kenney, 1984). Sheep may also select plant material of low leaf strength. Inoue *et. al.* (1989) found that animals consumed greater quantities, which was digested more rapidly in the rumen, of low strength ryegrass compared with high strength perennial ryegrass.

There is a definite preference for feeds which can be eaten faster; the degree of discrimination between feeds being greater when the potential intake rate of feeds being compared is low (Black and Kenney, 1984). However as some authors have found, that the preference for some feeds; such as dried clover pasture, was less than would be expected from the potential intake rate at which the feeds are eaten and suggested acceptability factors such as taste, odour or feel are also important.

2.9 OPTIMAL FORAGING THEORY.

The optimal foraging theory predicts that animals will choose a diet to maximise the intake of some nutrient currency while minimising the cost of foraging and exposure to predators (Illius, 1986).

In the case of ruminants the most important nutrient currency is likely to be energy to the correlation between the content of digestible organic matter in herbage tissue and contents of nitrogen and minerals. Selection of plant material with a low content of digestible organic matter in herbage tissues represents and avoidance of the less-digestible structural carbohydrates (Van Soest, 1968) cited by Edwards (1990). Illius (1986) stated that preference will be given for foods which give the highest intake per unit handling time. Diets often selected are sub optimal in comparison with the linear programming solution to the problem of the best nutrient mix (Illius, 1986). Therefore if an animal is to make an informal choice, and select a preferred diet, knowledge of the offered diet is required. One cannot assume that animals have complete nutritional knowledge, to optimise foraging in a variable environment and hence must sample to ascertain the relative values of food sources.

3.0 ANIMAL INTAKE AND PRODUCTION.

Animals often continue to graze preferred species when availability is poor and there is a resultant decrease in intake and productivity (Arnold, 1964a).The question then arises as to whether neglected species would be eaten if preferred species were absent.

Low live-weight gains of sheep grazing endophyte ryegrass (Fletcher, 1986) and decreased voluntary intake of steers grazing endophyte infected tall fescue (Goetsch *et. al.*, 1986) both indicate that increased animal intakes and production would be achieved on preferred pasture species. Brown (1990) supported this, publishing data showing live-weight gains of sheep grazing high preference species such as chicory and tall fescue compared with low preference species such as high endophyte ryegrass.

It is obvious that more work is required relating to preferences for pastures to animal intake and production in conjunction with work on determining pasture species preferences in sheep.

CHAPTER THREE
MATERIALS AND METHODS

This investigation took place within two main experimental areas:

1. Rate of intake trials with fresh cut herbage from Ashley Dene and Iverson Field.
2. Field grazing trials measuring the rate of decline in height of four grass species grown at Ashley Dene and six species in pure swards plus one sward mixture at Iverson Field.

3.1 RATE OF INTAKE TRIALS.

3.1.1 Experimental Animals.

Twelve Coopworth ewe hoggets were used to examine the effect of different pasture species and fertilisation of those species on the rate of intake. In autumn rate of intake trials one and two the hoggets were nine months old (approximate live weight = 25kg) and by rate of intake trial three in spring, they were about thirteen months old (approximate live weight = 37kg). Animals were housed in pens outside for one week and fed ad-libitum on a diet of meadow hay and fresh cut Moata tetraploid Italian ryegrass green feed for all three trials except pea straw was used instead of meadow hay in rate of intake trial three.

Plate 1. Animals in pens during rate of intake trial 1.

Three trials were conducted and they were:

* Rate of intake trial one which consisted of eight feeds cut from unfertilised and nitrogen fertilised grass at Ashley Dene, using eight sheep.
* Rate of intake trial two which consisted of six unfertilised grass species cut from Iversen Field, using all twelve sheep.
* Rate of intake trial three which consisted of ten feeds cut from two grass species which received different rates of nitrogen fertiliser at Ashley Dene, using ten sheep.

3.1.2 Feeds.

Herbage cut from plots consisted of leaf only with very little pseudostem using hand shears.

<u>Rate of intake trial 1</u> (7/5/93 - 15/5/93).
Rate of intake trial one consisted of Plant material from Ashley Dene. Each of the grass species were fertilised in April to simulate urine patches but only the unfertilised and nitrogen fertilised (500 Kg/ha of nitrogen) plots were fed to penned sheep. Pasture species fed were Wana cocksfoot (*Dactylis glomerata* L.), Maru phalaris (*Phalaris aquatica* L.), Roa tall fescue (*Festuca arundinacea* Schreb), and Yatsyn perennial ryegrass (*Lolium perenne* L.). All of the plant material was of equal age (approximately fifty days regrowth) and from the same site.

<u>Rate of intake trial 2</u> (7/5/93 - 16/5/93).
Rate of intake trial two consisted of plant material from Iversen Field. Since the location was different as well as maturity and soil fertility differences (table 4), feeds from this site were compared in a separate trial from those in rate of intake trial one.

Table 4: Soil fertility at Ashley Dene and Iversen Field.

Site	Treatment	pH	Ca	K	P	Mg	Na	S
Ashley Dene on Balmoral stony silt loam	No fertiliser	6.1	12	17	14	27	6	5
	Nitrogen fertilised	5.7	11	9	8	23	6	3
	N/K/S fertilised	5.8	9	19	8	18	4	3
Iverson Field on Wakanui silt loam	No fertiliser	6.1	11	12	27	26	6	4

N = Nitrogen　　Mg = Magnesium
K = Potassium　　Na = Sodium
S = Sulphur　　Ca = Calcium
P = Phosphorus

Note the soil fertility status at Iversen Field is similar to Ashley Dene except being higher in phosphorus. Also, sulphur was low at both Iversen Field and Ashley Dene.

Again leaf only was cut. Unfertilised grass was fed because of the small size of the fertilised plots (i.e. $0.1m^2$ simulated urine patch) which were going to be grazed as well. Reasons for the size of the fertilisations were mainly because of the limited size of the main plots and a continuation of a mowing trial occurring once the grazing preference experiment was finished. Herbage fed was Harkari mountain brome (*Bromus marginatus* Nees.), Roa tall fescue (*Festuca arundinacea* Schreb), Marsden perennial ryegrass (*Lolium perenne* * *Lolium multiflorum*), Maru phalaris (*Phalaris aquatica* L.), Wana cocksfoot (*Dactylis glomerata* L.) and Kahu timothy (*Phleum pratense* L.). All plant material was of equal age (approximately sixty days regrowth).

Rate of intake trial 3 (24/9/93 - 1/10/93).
Rate of intake trial three consisted of plant material from Ashley Dene as well but from a different location. Five different rates of nitrogen fertiliser was applied in early August (0, 50, 100, 200, and 400 Kg/ha of nitrogen) to two different established grass areas. The grass species were Wana cocksfoot (*Dactylis glomerata*) and Yatsyn perennial ryegrass (*Lolium perenne*). Again leaf only was feed and plant material was of equal age (approximately seventy days regrowth).

Description of plant material are outlined in tables 5-7. Leaf lengths ranged from 6-14cm in rate of intake trial 1, 6-15cm in rate of intake trial two, and 6-13cm in rate of intake trial three. Leaves were cut at the pseudostem height rather than being dissected from the stems and for this reason there was around 3 to 10% pseudostem remaining on the leaf material used in these feeding experiments. Also presented in tables 5-7 are percent leaf dry-matter which ranged from 16-24% in rate of intake trial one, 20-28% in rate of intake trial two, and 16-28% rate of intake trial three. Leaf nitrogen percent ranging from 2.16 to 5.22% for rate of intake trial three is also presented in table 7. The leaf material from rate of intake trial two contained around 5% dead leaves especially in the Kahu timothy material as well as some necrotic leaf tips especially the Hakari mountain brome. Lastly cocksfoot leaf material in trial three which was not fertilised with nitrogen was necrotic from frost damage.

Plant material was weighed into individual 50 gram feeds. These were either used within two hours or stored at 3°C for up to twelve hours.

Table 5: Description of the fresh 50 gram meals offered in rate of intake trial 1.

Species	Approx leaf length (cm)	Dry-Matter percent
Cocksfoot	6	24
Cocksfoot (+N)	9	20
Phalaris	10	20
Phalaris (+N)	14	16
Fescue	7	24
Fescue (+N)	9	22
Yatsyn ryegrass	6	24
Yatsyn ryegrass (+N)	7	20

Table 6: Descriptions of the fresh 50 gram meals offered in rate of intake trial 2.

Species	Approx leaf length (cm)	Dry-Matter percent
Mountain brome	13	26
Fescue	15	26
Marsden ryegrass	10	28
Phalaris	9	20
Cocksfoot	13	24
Timothy	6	28

Table 7: Descriptions of the fresh 50 gram meals offered in rate of intake trial 3.

Species	Rate of N (Kg/ha)	Approx. leaf length (cm)	Dry matter (%)	Leaf nitrogen (%)
Cocksfoot	0 50 100 200 400	7 7 8 9 12	28 23 23 23 23	2.83 3.61 3.80 4.33 5.20
Yatsyn ryegrass	0 50 100 200 400	6 8 11 13 13	28 23 20 20 16	2.16 3.04 3.07 3.59 4.48

The feeds were fed in two time periods. The morning feeding took place between 8:00am and 11:00am and the afternoon feeding between 2:00pm and 5:00pm. The amount consumed by the animals in the morning feeding was not considered enough to influence the afternoon feedings with a three hour fasting period between feedings.

3.1.3 Experimental Procedure.

Animals were denied access to feed for ten hours prior to rate of intake measurements. The measurements of eating rates were carried out by offering consecutive 50 gram meals of different feeds (plate 2). Only four forages were tested per sheep at one given feeding session within a two to three hour period for rate of intake trial one and only three forages for rate of intake trial two and only five forages for rate of intake trial three. The different feeds were fed in different systematic designs (i.e. Latin square matrix) so time of day did not influence the results, as well all feeds had equal chance of being fed first or last.

Plate 2: Weighing of 50 gram feeds in rate of intake trial 3.

Fresh sub-samples of all feeds offered to sheep in rate of intake experiments were taken when herbage was cut. Samples were oven dried at 80°C for two days to determine dry-matter percentages. Samples were then ground to <1mm particle size and analyzed for nitrogen, potassium and sulphur content at Ag Research Invermay Soil Fertility Service Laboratory.

3.1.4 Statistical Analysis.

Data was analyzed using "Genstat" statistical package. Anova and Reml procedures were performed to calculate the S.E.M and C.V%. The Duncans test was also calculated using tables to determine significant differences between intake rates of different plant material. The Sigmaplot regression facility was used when there was only one independent variable. The line of best fit was added to the plots and the parameter estimates and the R-value stored in the worksheet.

3.2 FIELD TRIAL.

3.2.1. Field trial 1 (21/5/93 - 28/5/93).

3.2.1.1. Experimental site/design.

Four replicates of each of seven grasses and herbs were over-sown into runout lucerne at the Lincoln University dry-land sheep farm, "Ashley Dene", in early September 1989. Plots 30m * 9m, were arranged side-by-side, each replicate occupying one quarter of the grid.

Three of these grass species had run out by autumn 1993 so measurements were only performed on four species: "Grasslands Wana" cocksfoot, "Grasslands Roa" tall fescue,"Grasslands Maru" phalaris, and Yatsyn perennial ryegrass which was known to have high levels of Lolium endophyte.

One replicate was not used as it was badly infested with twitch and had been severely attacked by grass grub. The total trial area available for grazing was 2.5ha of which only 1ha contained the plots of species being investigated.

The pastures were of average quality for fifty days regrowth, being slow grown over early autumn with growth rates of about 10 kg DM/ha/day. Plots in autumn were typical of a dryland stony Lismore soil pasture which is close to coming up for renewal. It was of low height with low tiller numbers (approx. 900/m^2), and a large amount of bare ground (approx. 20%) especially in the clumpy distribution of Wana cocksfoot and between drill rows of Yatsyn ryegrass. Mean pasture mass in autumn was about 1000 kg DM/ha. The pasture had also considerable amounts of residual reproductive stem, especially Maru phalaris and a high content of annual weeds such as dandelion and subterranean clover was present in plots other than those of Wana Cocksfoot and Yatsyn ryegrass.

3.2.1.2 Pre trial procedures.

Plots had not been grazed since April 4 1993. Within the main plots of each species contained three sub-plots (4m * 4m on two replicates and 2m * 2m on one replicate) were established of which two had earlier received fertiliser treatments (plate 3) and the other receiving no fertiliser on April 8 1993.

Plate 3: Pre-grazing phalaris main plot showing the two fertilised sub plots.

Table 8 illustrates the three treatments used. The third treatment with nitrogen, potassium and sulphur was believed to represent the effect of a urine patch.

Table 8: Treatment used in Field grazing trial 1.

Treatment	Fertilizer	Percent				Rate (Kg/ha)		
		N	P	K	S	N	K	S
1	None	-	-	-	-	-	-	-
2	Urea	46	-	-	-	500	-	-
3	Urea	46	-	-	-	500	-	-
	K_2SO_4	-	-	40	17		500	
	KCl	-	-	50	-	-		50

N = Nitrogen.
P = Phosphorus.
K = Potassium.
S = Sulphur.
K_2SO_4 = Potassium sulphate.
KCl = Potassium chloride.

A feed budget was carried out to determine the feed available and thus the number of sheep required to graze the area for seven days. Average pasture cover was 900 kg DM/ha, giving total available dry-matter, with a 400 kg DM/ha residual, of 1250 kg. This was estimated to feed 120 ewes for seven days, with a average daily intake of approximately 1.5 kg DM/ha/day.

Prior to the introduction of stock the height of leaf and pseudostem and the pasture mass of each sub-plot was measured. It was noted at the time that tiller number was reduced and amount of bare ground was increased slightly due to fertiliser burning especially in the plots which received potassium sulphate and chloride as well. Leaf height was measured using a sward height stick to record the height where the first three leaves touched the perspex disk. Pseudostem length was measured with a ruler. Ten leaf and pseudostem heights were recorded in each of the 4m by 4m sub-plots and only five in the 2m by 2m sub-plots. Care was taken to avoid patches of twitch as well as grass grub and urine patches from previous grazings.. Pasture mass of each sub-plot was measured by cutting two 0.1 m^2 quadrates from each plot. Sub samples were taken from the sub-plots for nitrogen, potassium and sulphur analysis. Photographs were taken of leaf heights before introduction of stock.

3.2.1.3 Experimental Animals.

One hundred and twenty Corridale ewes were used from the Lincoln "Ashley Dene" sheep farm. These ewes had previously been grazing on lucerne pasture.

3.2.1.4 Experimental procedure.

The Corridale ewes were introduced to the trial area the morning of the 21 May 1993.

Leaf height measurements were taken from all the sub-plots daily. Photographs were taken of leaf heights two days into the trial and after seven days grazing. As well as at the end of the trial period the heights of each sub-plot were recorded and the pasture mass estimated.

3.2.1.5 Statistical Analysis.

The rate of decline in height of each species and treatment was graphed and the means analyzed using the "Minitab" statistical package. Analysis of variance was performed to calculate the S.E.M for each day that heights were measured and the L.S.D to determine significant differences between the height of each species and treatment. As well C.V. was calculated.

3.2.2 Field trial 2 (21/5/93 - 28/5/93).

3.2.2.1 Experimental site/design.

Research plots were established at the Plant Science Department

Iversen Field Research Area at Lincoln University, Canterbury in February 1991. This 0.2ha paddock (plate 4) contained four replicates of twenty eight grass treatments (main plot treatments). Plots (1.6m * 5m) were arranged in a randomised block design.

Plate 4: Sheep on Iversen Field trial site during field grazing trial 2.

Only seven treatments were used in this study: "Grasslands Maru" phalaris (*Phalaris aquatica L.*), "Grasslands Wana" cocksfoot (*Dactylis glomerata L.*), "Grasslands Roa" tall fescue (*Festuca arundinacea Schreb*), "Grasslands Marsden" perennial ryegrass (*Lolium perenne * Lolium multi-florum*), "Grasslands Kahu" timothy (*Phleum pratensis*) "Grasslands Hakari" mountain brome (*Bromus marginatus*) and a Marsden perennial ryegrass and Kahu timothy mixture.

Compared with the Ashley Dene trial, herbage on offer was of very good quality for sixty days regrowth. Pasture was typical of a Wakanui Silt loam. It was of good height with a low tiller population, which varied between species and minimal amount of bare ground with the exception of the Hakari mountain brome and Wana cocksfoot (approx. 20%), giving a overall mean pasture mass of 2400 kg DM/ha. The pasture had average amounts of dry-matter (approx. 20%) except for Hakari mountain brome, and Kahu timothy being higher in dry-matter (approx. 40%) as this probably attributable to the haying type regime in previous experiments.

3.2.2.2 Pre trial procedure.

Plots had previously been used in mowing trials during the 1992/93 season. Plots were finally trimmed in March 1993 using a flail type mower to a uniform height of around 5cm. The aim was to obtain a similar pasture mass, dead material content, and height for all the grass treatments at the commencement of the experimental grazing.

Within the main plots of each of the seven selected pasture treatments, four subplots (0.1 m^2) were established of which three had earlier received fertiliser treatments and the other receiving no fertiliser on April 16 1993 (plate 5). Table 9 lists the four treatments used. The fourth treatment was believed to represent the effect of a urine patch with one exception, the sulphur amount was higher (205 kg/ha). Potassium chloride was not used in this trial due to the burning effects in Field trial one.

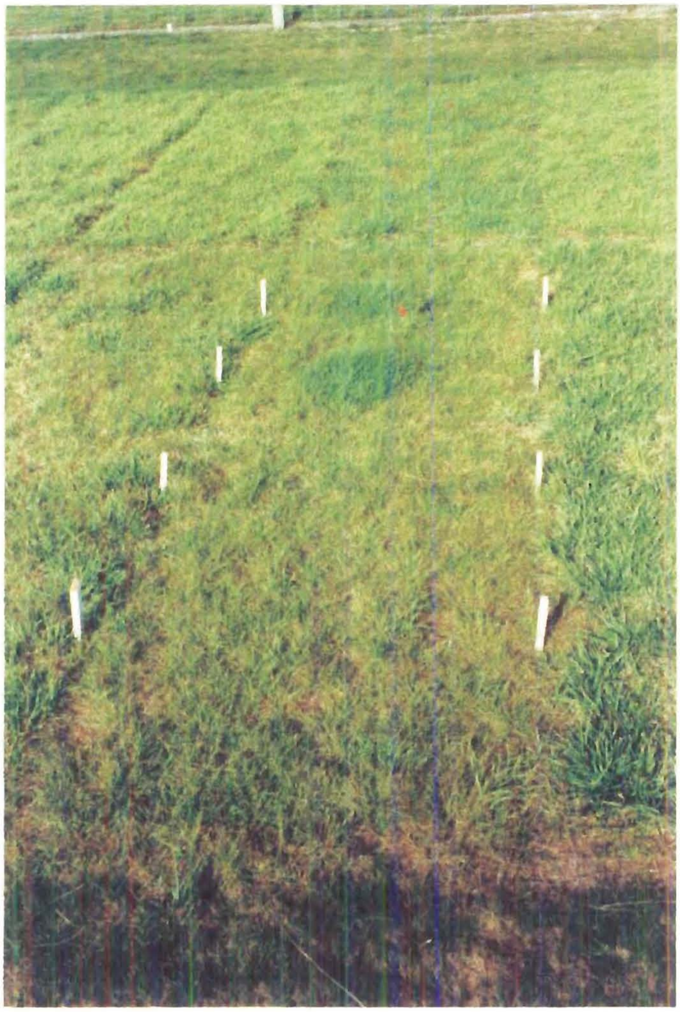


Plate 5: Pre-grazing Marsden ryegrass main plot showing the four sub plots.

Table 9: Treatments used in Field grazing trial 2.

Treatment	Fertilizer	Percent				Rate (Kg/ha)		
		N	P	K	S	N	K	S
1	None	-	-	-	-	-	-	-
2	Urea	46	-	-	-	500	-	-
3	K_2SO_4	-	-	40	17	-	500	205
4	Urea K_2SO_4	46 -	- -	- 40	- 17	- 500	- 500	- 205

A feed budget was carried out to determine the feed available and thus the number of sheep required to graze the area for seven days. Average pasture cover was 2300 kg DM/ha giving total available dry matter, with 800 kg DM/ha residual, of 1500 kg. This was estimated to feed thirty-four ewe hoggets for seven days, with a average daily intake of approximately 1.25 kg DM/ha/day.

Prior to the introduction of stock the height of leaf and pseudostem of each sub-plot was measured. Leaf height was measured again using a sward height stick and pseudostem length measured using a ruler. Three leaf and pseudostem measurements were recorded in each of the $0.1m^2$ sub-plots. Pasture mass was measured not in the sub-plots because of their size but in an area similar to the control sub-plot and because the fertilized sub-plots were approximately twice the height it was assumed pasture mass would be double. Pasture mass of each plot was measured by cutting $0.1m^2$ quadrat. Sub-samples were taken from the sub-plots for nitrogen potassium and sulphur analysis. Photographs were taken of leaf heights before stock were introduced.

3.2.2.3 Experimental Animals.
Thirty four Coopworth ewe hoggets were used, which had previously been grazing on chicory plots and then on a paddock of high endophyte Marsden ryegrass (plate 6).

Plate 6: Sheep grazing plots at Iversen Field during field grazing trial 2.

3.2.2.4 Experimental procedure.
The Coopworth ewe hoggets were introduced to the trial area the afternoon of the 21 May 1993.

Leaf height measurements were taken daily from all the sub-plots. Photographs were taken of leaf heights two days into the gazing trial and pseudostem heights post-grazing or after seven days grazing.

At the end of the trial period the heights of each sub-plot were recorded and the pasture mass estimated.

3.2.2.5 Statistical Analysis.

Refer to section 3.2.1.5.

3.2.3 Field trial Three (7/8/93 - 14/8/93).

3.2.3.1 Experimental site/design.

Experimental site was the same as Field trial 1 (refer to section 3.2.1.1). Herbage on offer was of different quality for seventy days regrowth, to field trial one in autumn. Pasture had been slowly grown over winter with an accumulation of frosted cocksfoot material. But much of the dead material had diminished and mean pasture cover was slightly higher, around 1100 kg DM/ha.

3.2.3.2 Pre trial procedure.

Plots had not been grazed since the end of Field trial 1 (28/5/93). Measurements as outlined earlier (refer 3.2.1.3) were taken in the three sub-plots, as well in real sheep urine patches.

A feed budget was again carried out and it was estimated that pasture available would feed eighty in-lamb ewes for one week.

3.2.3.3 Experimental Animals.

Eighty in-lamb Borderdale ewes were used from the Lincoln "Ashley Dene" sheep farm. These ewes had previously been grazing on turnips.

3.2.3.4 Experimental procedure.

The Borderdale ewes were introduced to the trial area the morning of the 7 August 1993. Measurements as outlined earlier (refer 3.2.1.4) were taken from the sub-plots daily.

3.2.3.5 Statistical Analysis.

Refer to section 3.2.1.5.

CHAPTER FOUR
RESULTS

4.1 RATE OF INTAKE TRIALS.

4.1.1 Rate of intake trial 1 (7/5/93 - 16/5/93).

Rate of intake trial one consisted of autumn leaf material from Ashley Dene. The intake rates of these are presented in table 10.

Table 10: Rate of wet matter (g WM/min) and dry matter (g DM/min) intakes of autumn cut fresh herbage in rate ofintake trial 1.

Grass Species	Feeding Rate (g/min)			
	Wet Matter		Dry Matter	
	Fertiliser treatment			
	O	N	O	N
Phalaris	17.1a	25.5a	3.42a	4.08a
Yatsyn Ryegrass	23.1a	23.7a	5.54a	4.74a
Cocksfoot	18.9a	22.1a	4.55a	4.10a
Fescue	13.8a	20.4a	3.09a	4.50a
SEmean	5.50		1.08	
CV Percent	60.9		55.4	

O = No fertiliser.

N = 500kg nitrogen/ha.

Table 10 shows on a wet and dry weight basis no significant differences in intake rates were found between species and fertiliser treatments. Note the very high CV percent.

4.1.2 Rate of intake trial 2 (7/5/93 - 17/5/93).

Rate of intake trial two consisted of autumn leaf material from Iversen field. The intake rates of these are presented in table 11.

Table 11: Rate of wet matter (g WM/min) and dry matter (g DM/min) intakes of autumn cut fresh herbage in rate of intake trial 2.

Grass Species	Feeding Rate (g/min)	
	Wet Matter	Dry Matter
Phalaris	43.2a	8.66a
Brome	34.3b	8.90a
Cocksfoot	33.9b	8.15a
Fescue	27.9c	7.26b
Marsden Ryegrass	27.5c	7.69a
Timothy	17.4d	4.87c
SEmean	1.90	0.45
CV Percent	36.5	12.3

Table 11 shows on a wet weight basis phalaris was eaten at an approximately 2.5 fold faster rate than timothy. On a dry weight basis, mountain brome and cocksfoot were eaten just as fast as phalaris which was 1.5 fold faster than timothy.

4.1.3 Rate of intake trial 3 (22/9/93 - 30/9/93).

Rate of intake trial three also consisted of spring leaf material from Ashley Dene. The intake rates of these are outlined in table 12 and figure 1.

Table 12: Rate of wet matter (g WM/min) and dry matter (g DM/min) intakes of spring cut fresh herbage in rate of intake trial 3.

Grass Species	Rate of N (kg/ha)	Feeding Rate (g/min)	
		Wet Matter	Dry Matter
Yatsyn ryegrass	0	32.7b	9.14a
	50	47.9a	11.02a
	100	43.7a	8.74b
	200	37.0b	7.39b
	400	39.7a	6.36c
Cocksfoot	0	23.4c	6.54c
	50	33.5b	7.70b
	100	31.1b	7.15b
	200	35.9b	8.26b
	400	46.2a	10.63a
S.E.M		2.89	0.651
CV percent		24.6	24.8

Table 12 shows that Yatsyn ryegrass which had previously been fertilised with 50, 100, and 400kg nitrogen/ha was eaten at a significantly faster rate than the other two rates on a wet matter basis. Figure 1 shows this inconsistent pattern with increasing nitrogen application rate. On a dry-matter basis however both Yatsyn ryegrass which was previously unfertilised and fertilised with 50kg nitrogen/ha were eaten at significantly faster rates. This was due the high dry-matter percent. Also, there was a trend of decreasing dry-matter intake rate with increasing nitrogen application rate (figure 1).

Cocksfoot which had previously been fertilised with 400kg nitrogen/ha was also eaten at an approximately two fold rate, than the unfertilised cocksfoot on a wet and dry-matter basis. Also, on a wet and dry-matter basis rate of intake of cocksfoot increased substantially with increasing nitrogen application rate (figure 1).

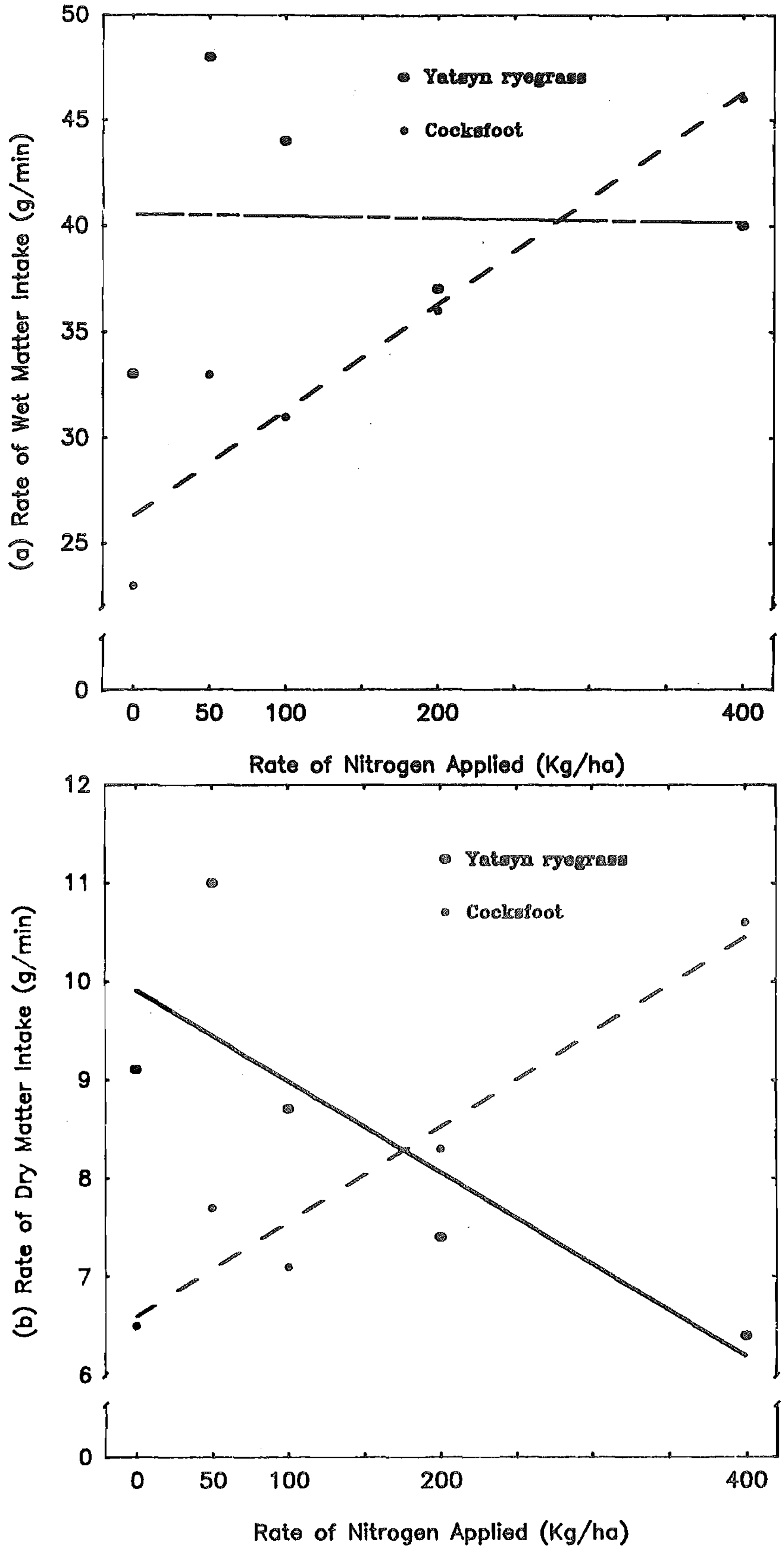


Figure 1. Rate of (a) wet matter and (b) dry matter intake versus level of nitrogen applied in rate of intake trial 3.

4.2 FIELD GRAZING TRIALS.

4.2.1 Field trial 1 (21/5/93 - 28/5/93).

4.2.1.1 Pasture mass.

The measured pre and post-grazing pasture mass for each species and fertiliser treatment is presented in table 13. The pre-grazing pasture masses of the unfertilised grasses especially fescue was considerable lower than the fertilised grasses. Post grazing pasture mass was estimated by eye appraisal. The unfertilised grasses were grazed to the lowest residual mass especially fescue, while the fertilised grasses especially cocksfoot were grazed to the highest (plate 7).

Plate 7: Pre and post-grazing pasture mass of nitrogen fertilised cocksfoot.

Table 13: Pre and post-grazing pasture mass of each species and fertiliser treatments in field trial 1 at Ashley Dene, during autumn.

Grass Species	Pasture mass (kg DM/ha)					
	Pre-graze			Post-graze		
	Fertilizer treatment			Fertilizer treatment		
	0	N	NKS	0	N	NKS
Phalaris	600	1200	900	500	630	570
Ryegrass	500	1050	1400	400	950	850
Fescue	300	800	750	250	460	430
Cocksfoot	800	1250	1350	700	1000	1100
S.E.M	101			-		

O = No fertiliser.
N = 500kg nitrogen/ha.
NKS = 500kg nitrogen, 500kg potassium, and 50kg sulphur/ha.

4.2.1.2 Pasture height.

The decline in heights of the four species and fertiliser treatments, over the grazing duration is presented in Figures 2-5. The height consumed after two days grazing and the grass height after seven days grazing is also presented in tables 14-15. Plate 8 shows the height of unfertilised and nitrogen fertilised phalaris pre-grazing, after two days grazing and post-grazing.

The height of phalaris decreased rapidly, and it continued to decline rapidly through the entire grazing duration (figure 2). However, there was no difference between treatments (table 14) as all exhibited similar rates of decline (plate 8) and by the end of the trial leaf heights were very similar (table 15).

Cocksfoot was greatly reduced within the first two days, but from then on the rate of decline was not so dramatic (figure 3). Again there was not great differences between treatments, except for the large reduction in height of the fertilised plots by day one, with similar leaf height by the end of the grazing trial (table 15).

Similar trends were demonstrated with Yatsyn ryegrass (figure 4 and table 14-15) except between day two and four where the fertilised plots were grazed significantly lower.

Fescue rate of decline was not so marked (table 14) and partly due to the lower initial height (figure 5). But again there was no real difference between treatments and by the end of the grazing trial leaf heights were very similar (table 15).

The comparisons between species for each of the three treatments is shown in the appendix. Appendix 1-3 clearly demonstrates the rapid decrease in height of phalaris in all the three treatments.

4.2.1.3 Nutrient status.

In plots that did not receive fertiliser the percentage nitrogen, potassium and sulphur of Yatsyn ryegrass plant material was lower than the other three species (table 16). Also, phalaris had the lowest percentage phosphorous compared with the other three species.

Percentage nitrogen of plant material for all species was increased, especially cocksfoot, by the application of nitrogen and the nitrogen/potassium/sulphur treatment. Phosphorous however was diluted with the application of either the nitrogen or nitrogen/potassium/sulphur treatment. Also with the application of the nitrogen treatments, sulphur was diluted but increased with the nitrogen/potassium/sulphur treatment. Potassium percentage like nitrogen also increased with the application of fertiliser, but with the exception of the fescue nitrogen/potassium/sulphur treatment.

The real urine patch of Yatsyn plant material was similar in nutrient content of the nitrogen/potassium/sulphur fertiliser treatment.

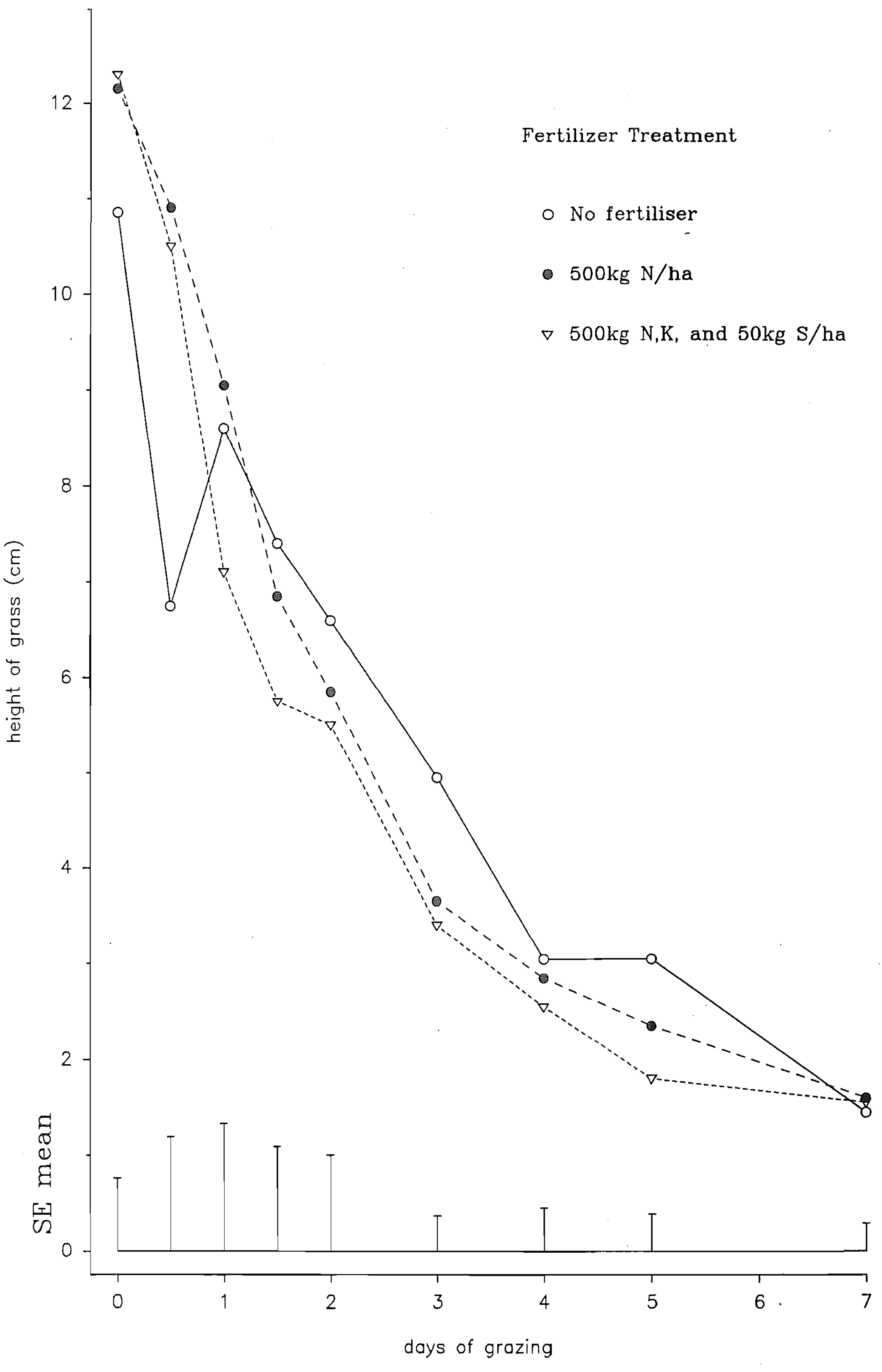


Figure 2. Decline in Phalaris height over the autumn grazing period in field trial 1 at Ashley Dene.

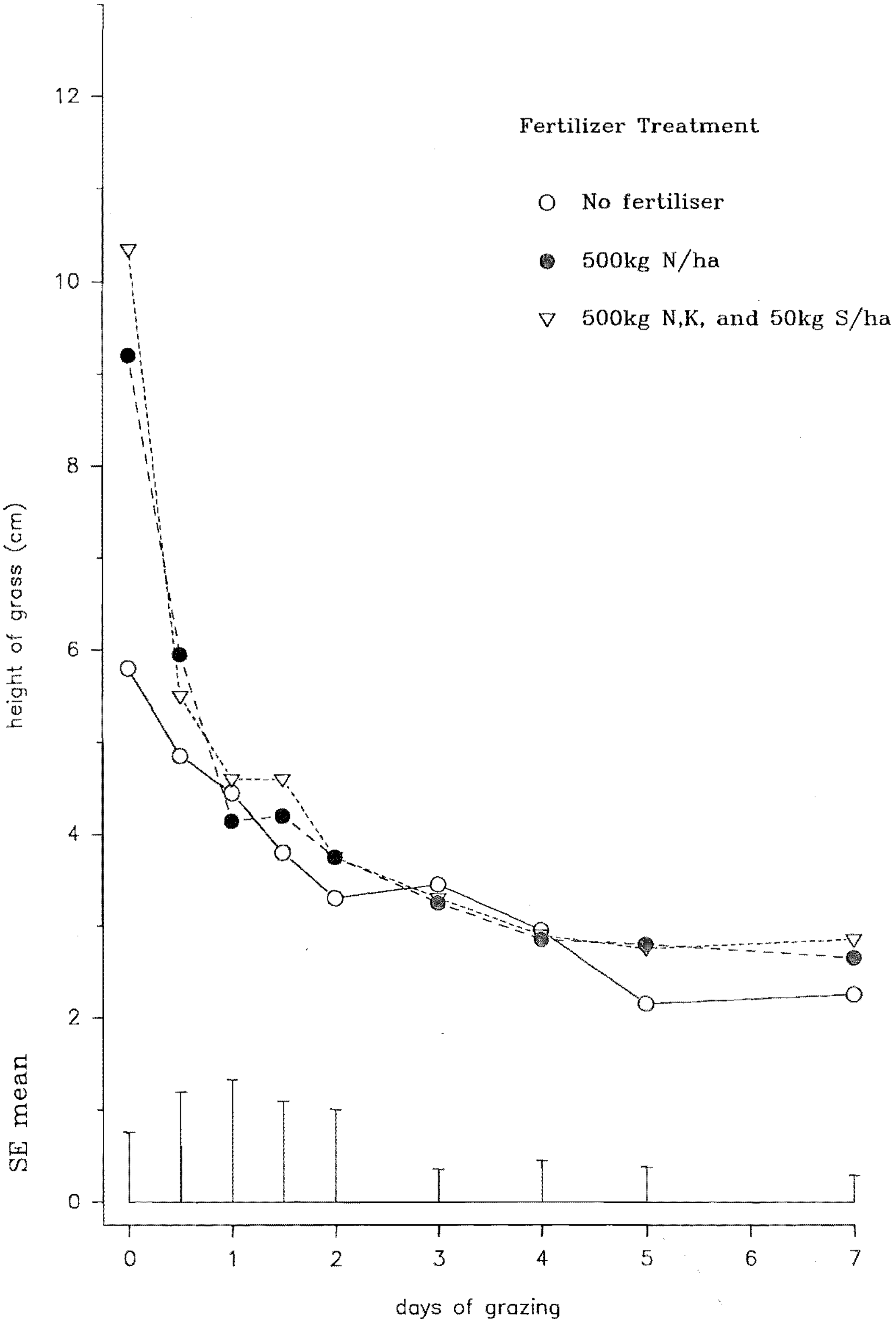


Figure 3. Decline in Cocksfoot height over the autumn grazing period in field trial 1 at Ashley Dene.

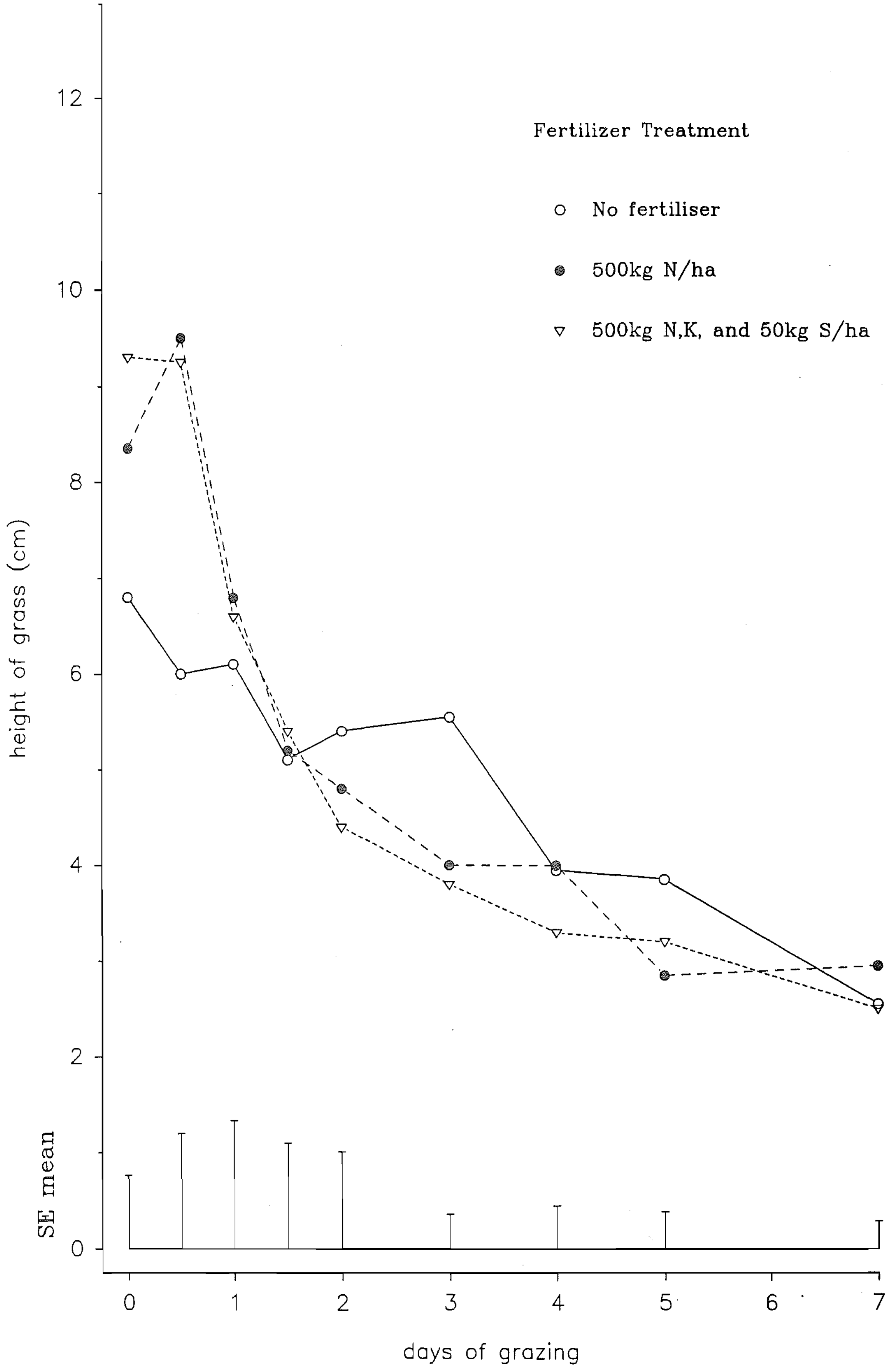


Figure 4. Decline in Yatsyn ryegrass height over the autumn grazing period in field trial 1 at Ashley Dene.

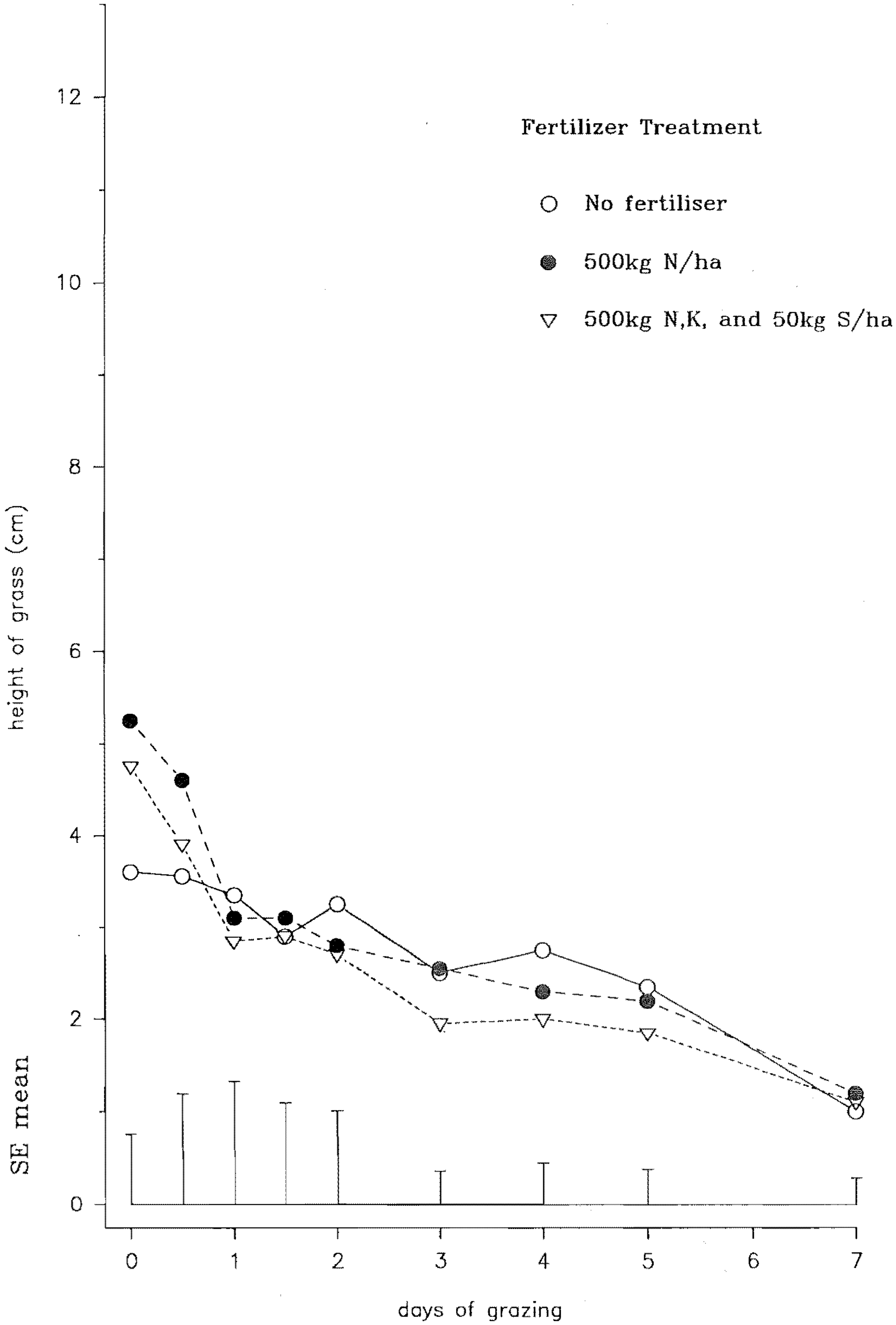


Figure 5. Decline in Fescue height over the autumn grazing period in field trial 1 at Ashley Dene.

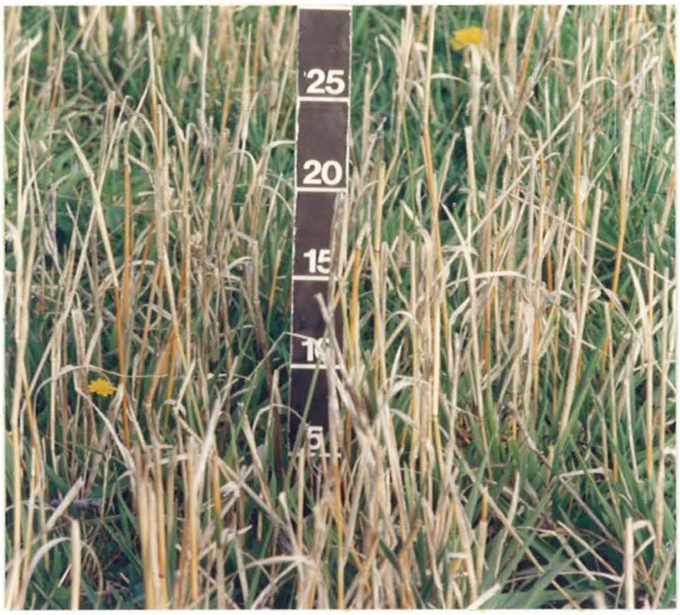
Table 14: Grass leaf height consumed (cm) by day two, for each species and fertiliser treatment in field trial 1 at Ashley Dene, during autumn.

Grass Species	Fertilizer Treatment		
	0	N	NKS
Phalaris	4.25	5.05	5.00
Yatsyn Ryegrass	1.40	4.70	4.85
Cocksfoot	2.50	2.20	1.75
Fescue	0.35	1.80	1.20
SEmean	0.41		
CV Percent	19.9		
LSD for the same level of	Grass		1.34
	Fertilizer		1.34

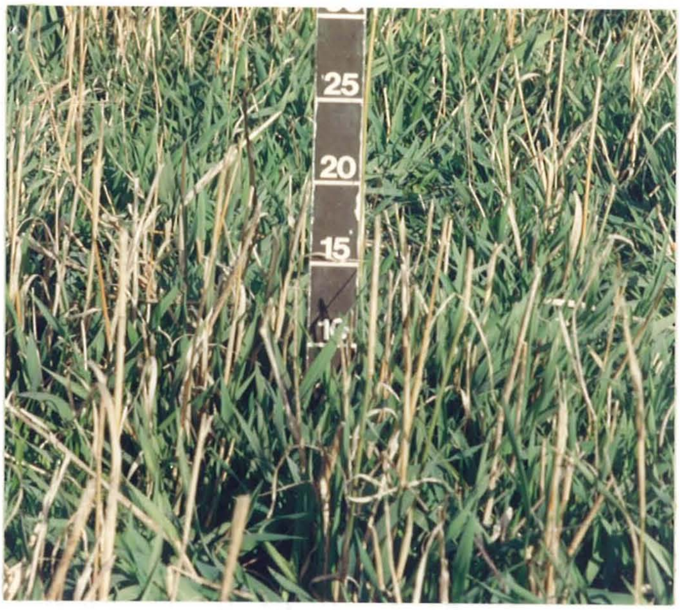
Table 15: Grass leaf height (cm) after seven days grazing, for each species and fertiliser treatment in field trial 1 at Ashley Dene, during autumn.

Grass Species	Fertilizer Treatment		
	0	N	NKS
Phalaris	1.45	1.60	1.55
Yatsyn Ryegrass	2.55	2.95	2.50
Cocksfoot	2.25	2.65	2.85
Fescue	1.00	1.20	1.10
SEmean	1.37		
CV Percent	9.8		
LSD for the same level of	Grass		0.45
	Fertilizer		0.93

(a)



(d)



(b)

(e)

(c)

(f)

Plate 8: Height of unfertilised phalaris (a) pre-grazing (b) after two days grazing (c) post-grazing, and nitrogen fertilised phalaris (d) pre-grazing (e) after two days grazing (f) post-grazing in field trial 1.

Table 16: Percentage of nitrogen, phosphorous, sulphur, and potassium in autumn herbage for each species and fertiliser treatment for fifty days regrowth in field trial 1 at Ashley Dene.

Species	Fertiliser treatment	Percentage (%).			
		N	P	S	K
Yatsyn ryegrass	O	3.12	0.40	0.30	3.18
	N	5.33	0.29	0.22	3.38
	NKS	4.94	0.24	0.40	3.75
	Urine*	4.30	0.30	0.32	3.80
Phalaris	O	4.42	0.29	0.33	3.90
	N	5.65	0.29	0.23	4.36
	NKS	5.95	0.28	0.45	5.00
Cocksfoot	O	4.35	0.43	0.33	3.57
	N	6.30	0.33	0.27	4.05
	NKS	6.14	0.37	0.39	4.63
Fescue	O	4.14	0.35	0.37	3.91
	N	5.18	0.35	0.34	4.16
	NKS	4.56	0.30	0.39	3.52

N.B Urine* = Herbage collected from real urine patches at Ashley Dene.

4.2.1.4 Pseudostem.

Pre and post-grazing pseudostem heights for each species and fertiliser treatment is presented in table 17.

Table 17: Pre and post-grazing pseudostem heights for each species and fertiliser treatment in field trial 1 at Ashley Dene, during autumn.

Grass Species	Pseudostem Height (mm)					
	Pre-grazing			Post-grazing		
	Fertilizer Treatment					
	0	N	NKS	0	N	NKS
Phalaris	18.8	24.0	16.0	16.0	23.5	27.0
Yatsyn Ryegrass	11.3	28.1	27.5	8.8	15.0	14.5
Cocksfoot	8.0	21.6	14.9	17.0	21.4	18.5
Fescue	7.8	10.6	11.3	7.5	12.8	14.7
SEmean	6.44			4.21		
CV Percent	49.2			21.8		
LSD for the same level of	Grass		18.9	8.26		
	Fertilizer		21.0	13.7		

Yatsyn ryegrass pseudostem reduced considerably over the grazing period especially when fertilised (around 13 mm). However, the other three grasses were not considerably reduced or even increased in height due to daily increments of growth.

4.2.2 Field trial 2 (21/5/93 - 28/5/93).

4.2.2.1 Pasture Mass.

Pre and post-grazing pasture mass for each species are given in table 18. Since fertilised plots could not be measured, it can be assumed they were double or more in mass, since they were taller and more dense. It was evident by day two that fertilised plots (with exception of the potassium/sulphur plots) had been grazed to a low pasture mass while substantial amounts of unfertilised plots still remained ungrazed. Fescue and cocksfoot pasture masses were also the greatest post-grazing.

Table 18: Pre and post-grazing pasture mass for each species in field trial 2 at Iversen Field, during autumn.

Species	Pasture mass (kg DM/ha)	
	Pre-graze	Post-graze
Mountain brome	2050	850
Fescue	2450	1100
Marsden ryegrass	2250	600
Phalaris	2150	800
Cocksfoot	2100	1050
Timothy	2150	850
Ryegrass/Timothy	2150	900
S.E.M	63	-

4.2.2.2 Pasture heights.

The decline in heights of the six species and fertiliser treatments, over the grazing duration is presented in figures 6-12. The height consumed after two days grazing and the grass height after seven days grazing is also presented in tables 19-20. Plates 9 and 10 show the heights of unfertilised and nitrogen fertilised phalaris and Marsden ryegrass pre-grazing, after two days grazing and post-grazing.

The height of phalaris decreased dramatically over the first two days (table 19) and it continued to decrease to the very end of the grazing trial (figure 6). There was no great differences between treatments (plate 9) except in the first day where the plots which had earlier received nitrogen, and nitrogen/potassium/sulphur were dramatically reduced in height. By the end of the grazing trial leaf heights were very similar with the exception of the potassium/sulphur plots which were significantly higher (table 19).

Cocksfoot plots that had earlier received nitrogen, and nitrogen/potassium/sulphur, was dramatically reduced in the first few days (table 19) but this continued right through to day three (figure 7). After day three there were no differences between treatments, with leaf heights similar at the end of the grazing trial except for the potassium/sulphur plots being significantly higher.

Similar trends to cocksfoot were demonstrated for Marsden ryegrass (figure 8) except the nitrogen and nitrogen/potassium/sulphur plots after the first day declined at the same rate as the others (plate 10). Also, the unfertilised Marsden ryegrass reduction in height over the first day was probably more marked compared with the unfertilised cocksfoot. As well leaf heights by the end of the grazing trial were similar except for the unfertilised plots which were significantly higher (table 20).

Fescue was also very similar to cocksfoot except the differences between treatments during the first days were not as marked (figure 9).

With mountain brome there were distinct differences between the unfertilised or potassium/sulphur plots (table 19-20), and the nitrogen or the nitrogen/potassium/sulphur plots even though rate of decline was similar (figure 9) through the entire grazing period.

Timothy showed no distinct differences between treatments except for the dramatic reduction of the nitrogen and nitrogen/potassium/sulphur plots in the first day (figure 11). Therefore, leaf heights at the end of the grazing trial were very similar (table 20). The same trend was also demonstrated in the timothy and Marsden ryegrass mixture (figure 12).

The comparisons between species for each of the four treatments is shown in the appendix. Appendix 4-7 clearly shows that all species with the addition of nitrogen and nitrogen/potassium/sulphur treatments, are significantly reduced to low levels within the first few days.

4.2.2.3 Nutrient status.

In plots that did not receive fertiliser the percentage of nitrogen and phosphorous of Marsden ryegrass plant material was lower than the other five species (table 21). Also, timothy had the lowest percentage sulphur and potassium.

Percentage nitrogen of plant material was increased by either the application of nitrogen or nitrogen/potassium/sulphur fertiliser. Phosphorous percentage of plant material was however diluted with the application of nitrogen or nitrogen/potassium/sulphur fertiliser. Percentage sulphur of plant material was also diluted, by the application of the nitrogen fertiliser, but with the nitrogen/potassium/sulphur treatment, sulphur was increased. Percentage potassium increased, except cocksfoot, with the addition of the nitrogen treatment. With the nitrogen/potassium/sulphur treatment there were only three species (Marsden ryegrass, phalaris, and timothy) where percentage potassium was increased.

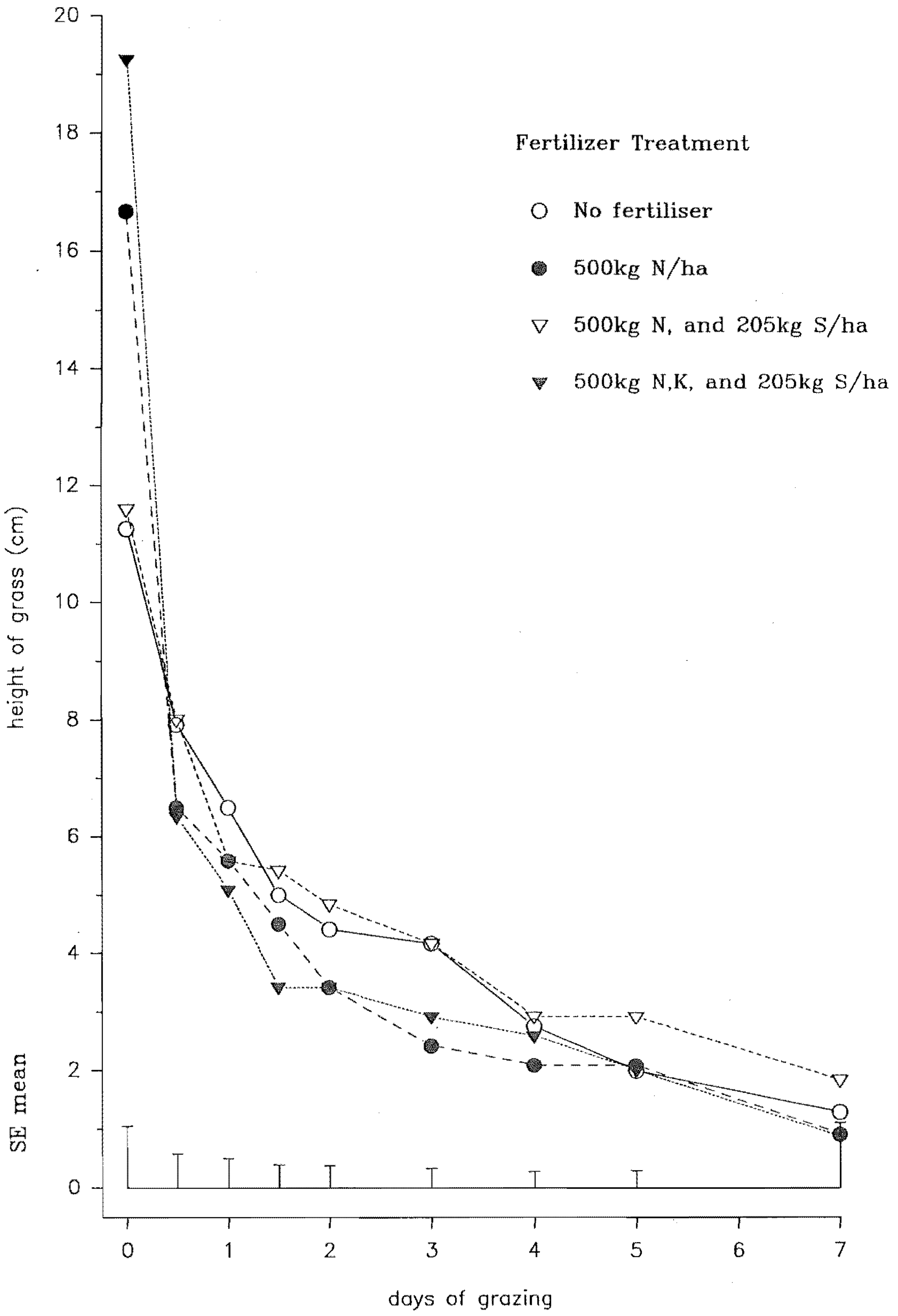


Figure 6. Decline in Phalaris height over the autumn grazing period in field trial 2 at Iversen Field.

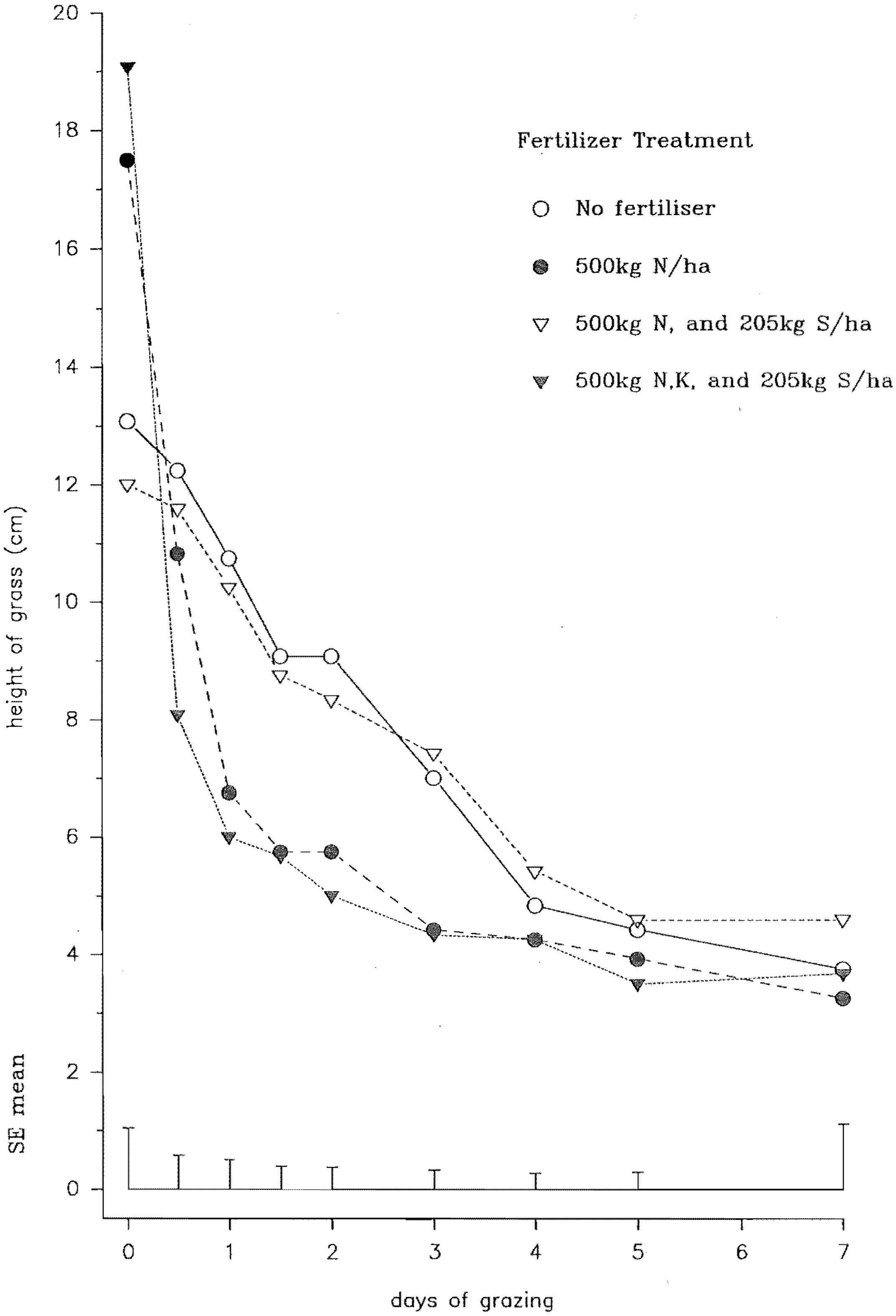


Figure 7. Decline in Cocksfoot height over the autumn grazing period in field trial 2 at Iversen Field.

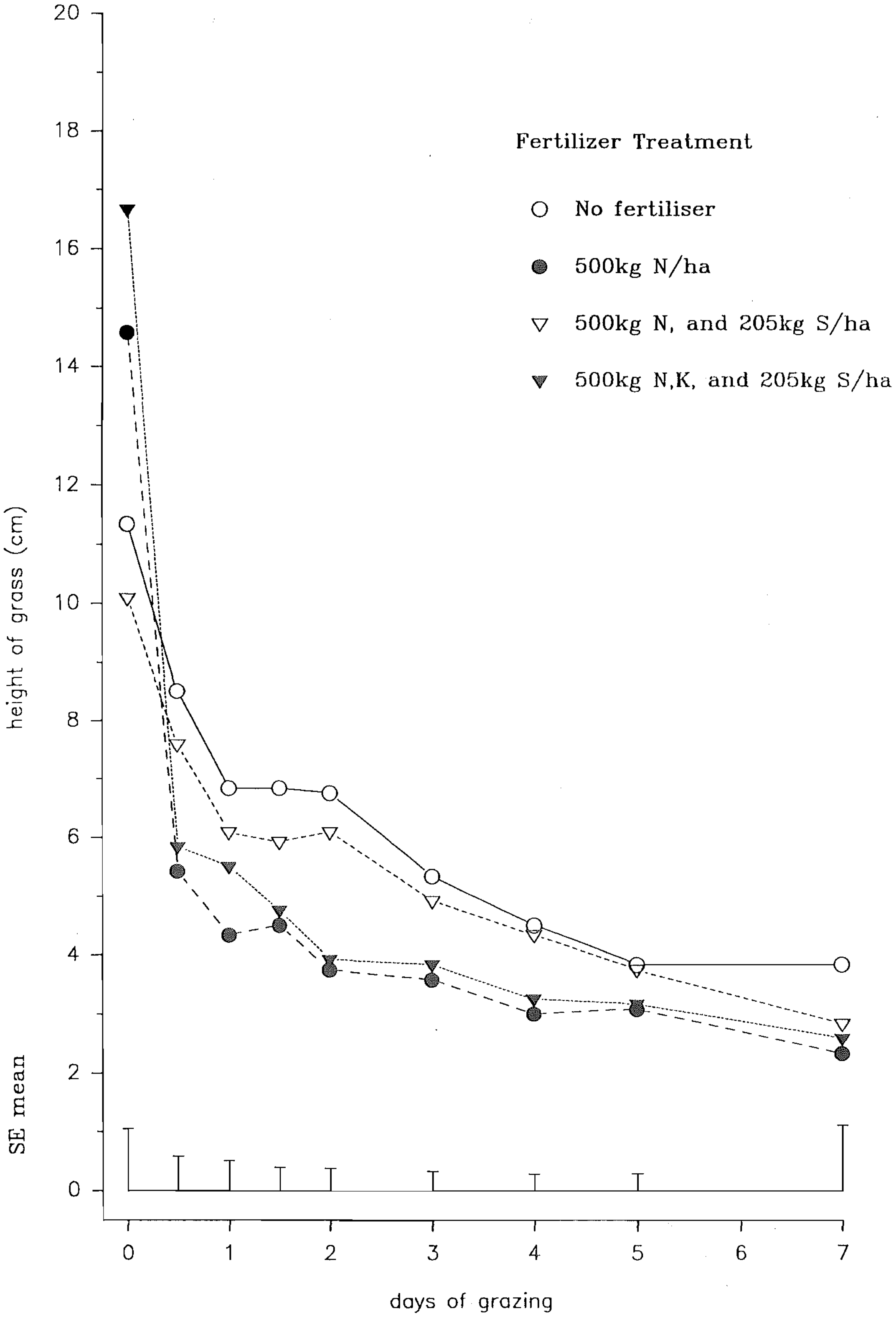


Figure 8. Decline in Marsden ryegrass height over the autumn grazing period in field trial 2 at Iversen Field.

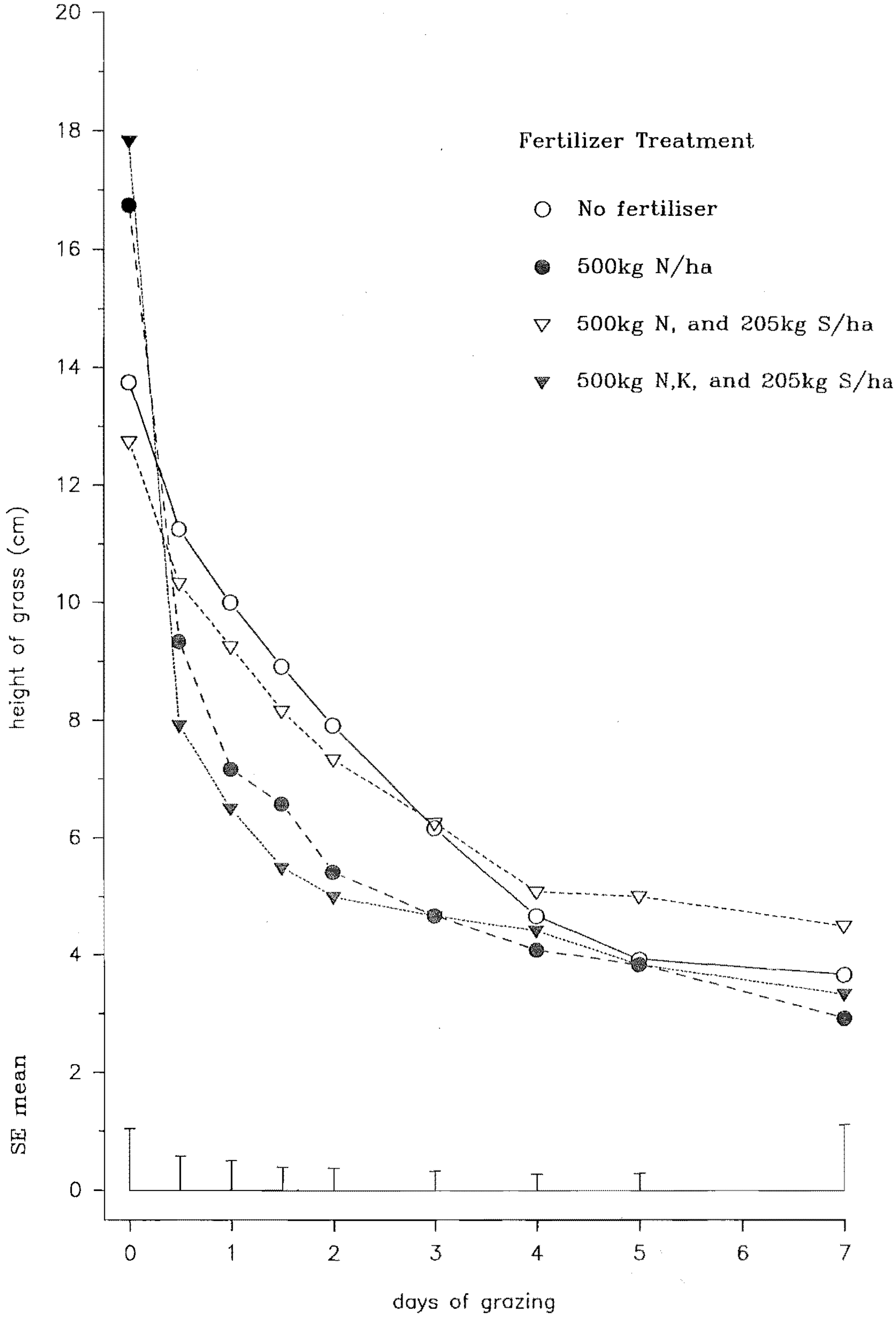


Figure 9. Decline in Fescue height over the autumn grazing period in field trial 2 at Iversen Field.

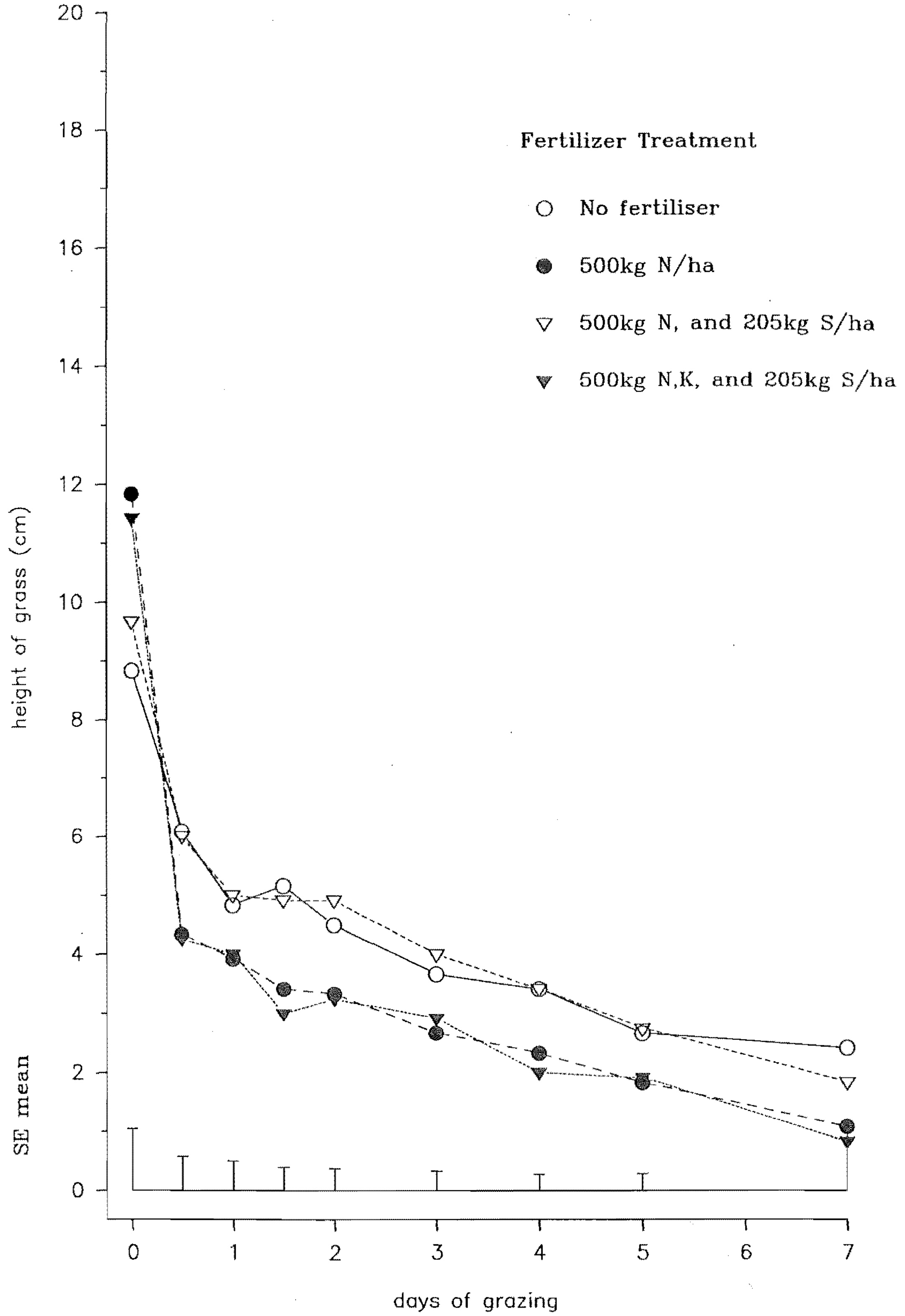


Figure 10. Decline in Mountain Brome height over the autumn grazing period in field trial 2 at Iversen Field.

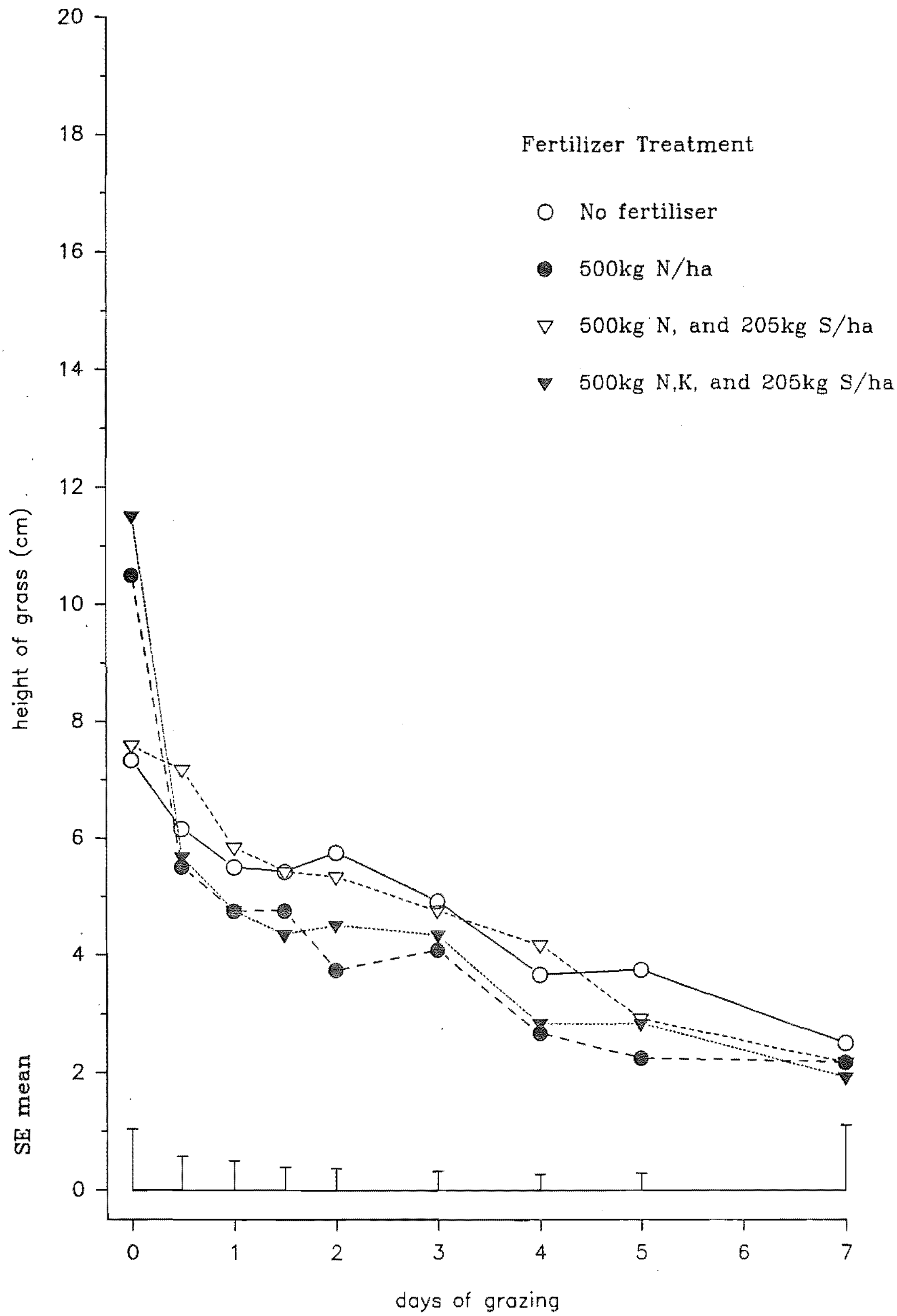


Figure 11. Decline in Timothy height over the autumn grazing period in field trial 2 at Iversen Field.

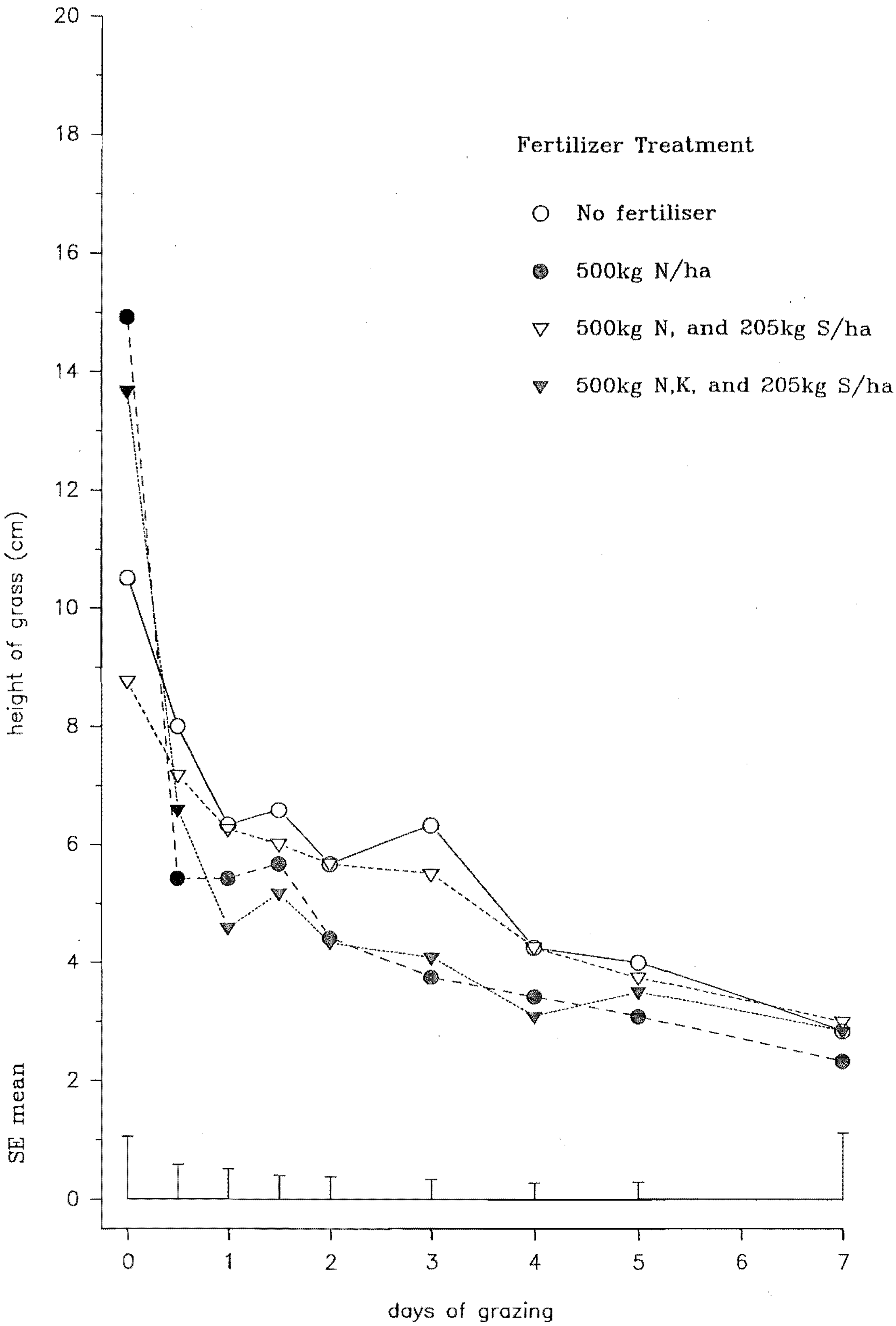


Figure 12. Decline in Timothy mix height over the autumn grazing period in field trial 2 at Iversen Field.

Table 19: Grass leaf height consumed (cm) by day two, for each species and fertiliser treatment in field trial 2 at Iversen Field, during autumn.

Grass Species	Fertilizer Treatment			
	0	N	KS	NKS
Mountain Brome	4.33	8.50	4.78	8.15
Fescue	5.80	11.3	5.40	12.9
Marsden Ryegrass	4.60	10.9	4.03	12.8
Phalaris	6.83	13.2	6.75	15.8
Cocksfoot	4.00	11.8	3.65	14.1
Timothy	1.58	6.73	2.25	7.00
Timothy/Ryegrass	4.85	10.5	3.08	9.33
SEmean	0.99			
CV Percent	25.7			
LSD for the same level of	Grass			2.49
	Fertilizer			3.15

Table 20: Grass leaf height (cm) after seven days grazing, for each species and fertiliser treatment in field trial 2 at Iversen Field, during autumn.

Grass Species	Fertilizer Treatment			
	0	N	KS	NKS
Mountain Brome	2.43	1.08	1.83	0.83
Fescue	3.68	2.93	4.50	3.23
Marsden Ryegrass	3.85	2.35	2.83	2.60
Phalaris	1.28	0.93	1.85	0.88
Cocksfoot	3.73	3.25	4.60	3.65
Timothy	2.53	2.18	2.20	1.93
Timothy/Ryegrass	2.80	2.33	3.00	2.83
SEmean	0.26			
CV Percent	20.1			
LSD for the same level of	Grass			0.75
	Fertilizer			0.84

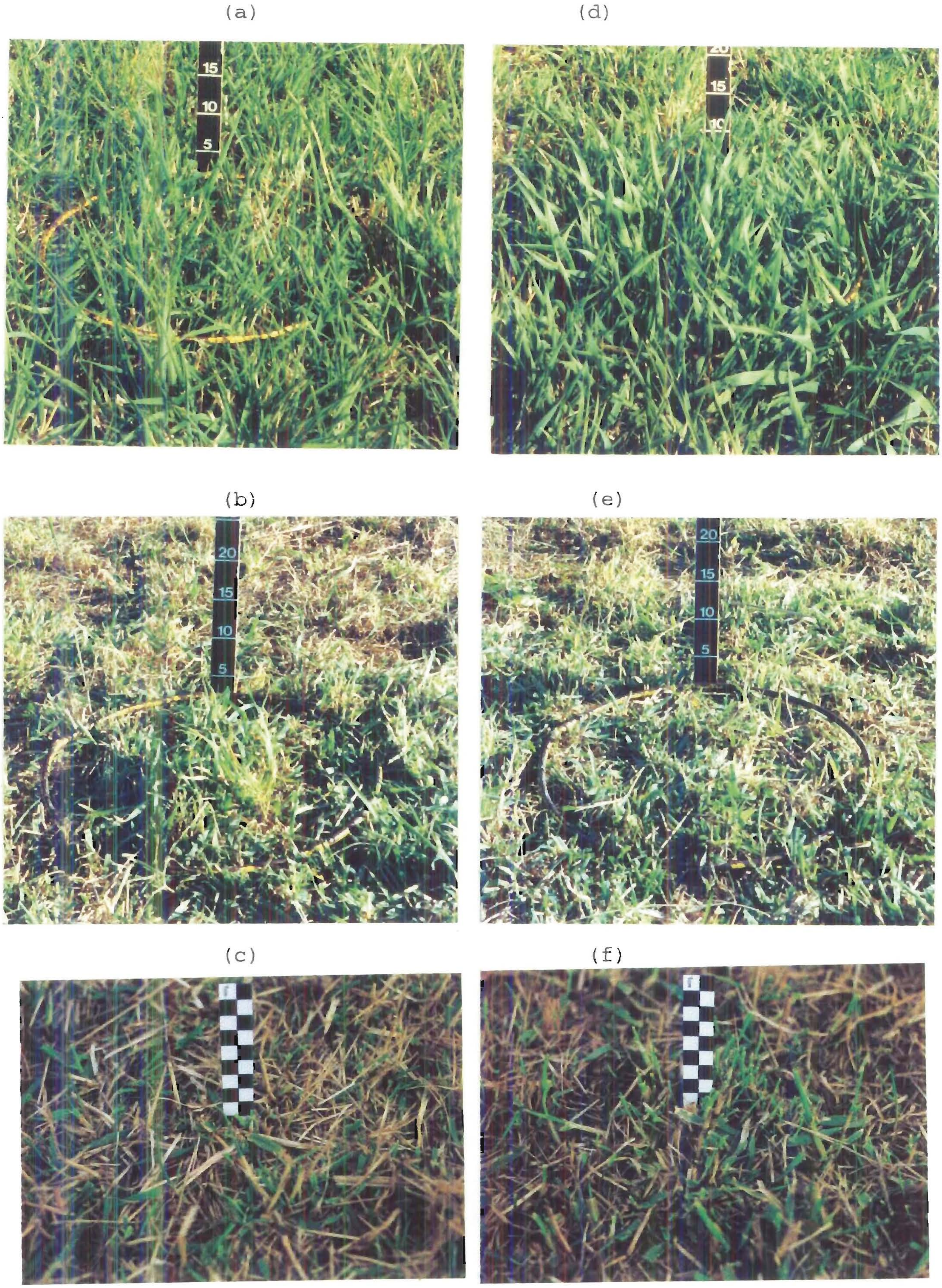
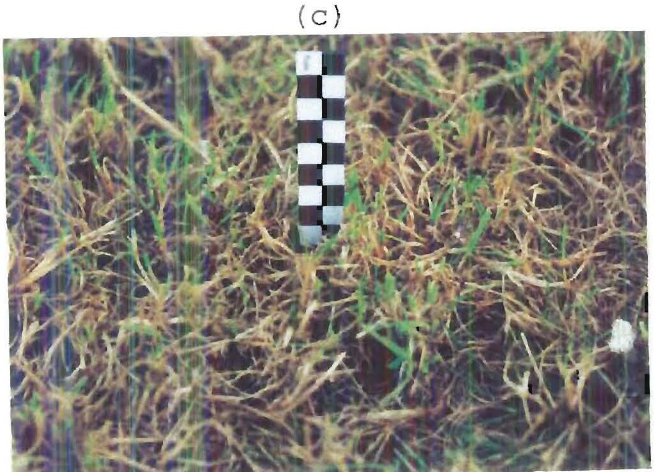


Plate 9: Height of unfertilised phalaris (a) pre-grazing (b) after two days grazing (c) post-grazing, and nitrogen fertilised phalaris (d) pre-grazing (e) after two days grazing (f) post-grazing in field trial 2.

(a)

(b)

(c)



(d)

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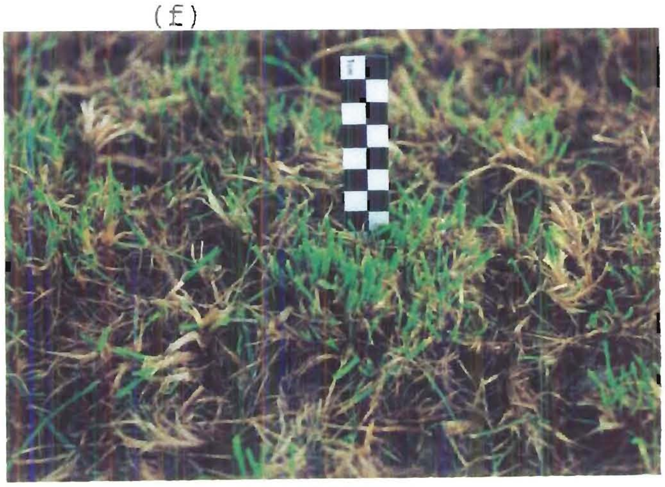

Plate 10: Height of unfertilised Marsden ryegrass (a) pre-grazing (b) after two days grazing (c) post-grazing, and nitrogen fertilised Marsden ryegrass (d) pre-grazing (e) after two days grazing (f) post-grazing in field trial 1.

Table 21: Percentage of nitrogen, phosphorous, sulphur, and potassium in autumn herbage for six species and three fertiliser treatments for sixty days regrowth in field trial 2 at Iversen Field.

Species	Fertiliser treatment	Percentage (%).			
		N	P	S	K
Marsden ryegrass	O	2.44	0.43	0.48	2.72
	N	4.59	0.33	0.39	3.36
	NKS	4.75	0.31	0.56	3.65
Phalaris	O	3.33	0.46	0.48	3.43
	N	4.58	0.37	0.38	3.62
	NKS	5.00	0.32	0.57	3.55
Cocksfoot	O	3.69	0.50	0.48	2.99
	N	5.03	0.42	0.40	2.68
	NKS	5.06	0.36	0.63	2.93
Fescue	O	2.80	0.47	0.38	2.96
	N	3.80	0.37	0.33	3.42
	NKS	3.28	0.39	0.46	2.88
Mountain Brome	O	3.89	0.44	0.41	3.10
	N	5.20	0.33	0.36	3.72
	NKS	5.29	0.32	0.37	2.84
Timothy	O	3.14	0.47	0.36	2.64
	N	5.84	0.38	0.30	2.98
	NKS	5.14	0.36	0.41	3.30

N.B. The potassium/sulphur treatment was not analyzed.

4.2.2.4 Pseudostem.

Pre and post-grazing pseudostem heights for each species and fertiliser treatment is presented in table 22.

Table 22: Pre and post-grazing pseudostem heights for each species and fertiliser treatment in field trial 2 at Iversen Field, during autumn.

Grass Species	Pseudostem Height (mm)							
	Pre-grazing				Post-grazing			
	Fertilizer Treatment							
	0	N	KS	NKS	0	N	KS	NKS
Mountain Brome	28.3	37.5	31.8	40.8	19.6	11.7	17.9	8.8
Fescue	37.5	46.8	36.8	50.3	34.2	26.2	37.5	29.6
Marsden Ryegrass	27.5	34.3	33.3	46.5	25.4	16.3	24.6	18.8
Phalaris	23.3	47.3	31.8	64.3	15.0	10.0	12.5	10.0
Cocksfoot	27.3	43.5	33.3	47.5	25.8	27.9	28.7	30.4
Timothy	20.5	34.3	18.0	34.0	22.9	18.8	24.6	21.3
Timothy/Ryegrass	26.5	37.5	30.5	38.5	23.3	19.2	26.3	22.1
SEmean	3.30				2.84			
CV Percent	18.2				26.1			
LSD for the same level of	Grass			9.36	8.03			
	Fertilizer			10.8	8.96			

The pseudostems from the plots which received either nitrogen or nitrogen/potassium/sulphur were considerably reduced after seven days grazing. Only two species (mountain brome and phalaris) of the plots which received the potassium/sulphur treatment were considerably reduced and none of the species which were unfertilised.

4.2.3 Field trial 3 (7/8/93 - 14/8/93).

4.2.3.1 Pasture mass.

The measured pre-grazing pasture mass for each species and fertiliser treatment as well as real urine patch masses are presented in table 23. The pasture masses of the unfertilised grasses were considerable lower than the fertilised grasses or the real urine patch grasses. Yatsyn ryegrass pasture mass was consistently lower than the other grasses for all the fertiliser treatments. Also the nitrogen and nitrogen/potassium/sulphur fertilised grasses were slightly higher than the real urine patch masses.

Table 23: Pre-grazing pasture mass of each species and fertiliser treatment in field trial 3 at Ashley Dene, during spring.

Grass Species.	Pre-graze pasture mass (kg DM/ha). Fertiliser treatments.			
	O	N	NKS	Urine*
Phalaris	800	1300	1600	1300
Yatsyn ryegrass	500	850	1400	1000
Fescue	500	1300	1500	1000
Cocksfoot	600	1200	1600	1000
S.E.M.	354			

N.B. Urine* = Real urine patch mass.

4.2.3.2 Pasture heights.

The decline in heights of the four species and fertiliser treatments, over the grazing duration are presented in Figures 13-16. The height consumed after two days grazing and the grass height after seven days grazing is also presented in Tables 24-25.

The height of phalaris which had earlier received nitrogen and nitrogen/potassium /sulphur decreased rapidly over the first few days (table 24) and from then on height was not so dramatically reduced (figure 13). The urine patch was not reduced in height dramatically until day three and the same for the unfertilised plots, except the reduction was not as marked since initial leaf heights were considerably lower. However, by the end of the grazing duration the leaf heights were very similar (table 25).

Cocksfoot demonstrated similar trends except for the dramatic reduction in height of the nitrogen/potassium/sulphur plots by day two (table 24), but initial leaf height was much higher than the others (figure 14). However, again by the end of the grazing duration the leaf heights were very similar (table 24).

Both Yatsyn ryegrass and fescue also demonstrated similar trends (figure 15-16) perhaps not quite as dramatic (table 24) but this is mainly due to the lower initial leaf height. Therefore, by the end of the grazing duration leaf heights in the treatments for both species were similar (table 25).

4.2.3.3 Nutrient status.

In plots that did not receive fertiliser the percentage nitrogen of Yatsyn ryegrass, percentage phosphorus of phalaris, percentage sulphur of fescue, and percentage potassium of cocksfoot plant material was lower than the other four species (table 26).

Percentage nitrogen of plant material was increased by the application of either nitrogen or nitrogen/potassium/sulphur fertiliser. Phosphorous percentage was also increased by the application of either nitrogen or nitrogen/potassium/sulphur fertiliser except for phalaris and fescue in the latter treatment. The application of nitrogen also diluted the sulphur percentage like in trial one and two as well as the nitrogen/potassium/sulphur treatment increasing percentage sulphur except in phalaris and fescue plant material. The potassium percentage was also diluted with the application of nitrogen and with two species (phalaris and fescue) following the application of nitrogen/potassium/sulphur.

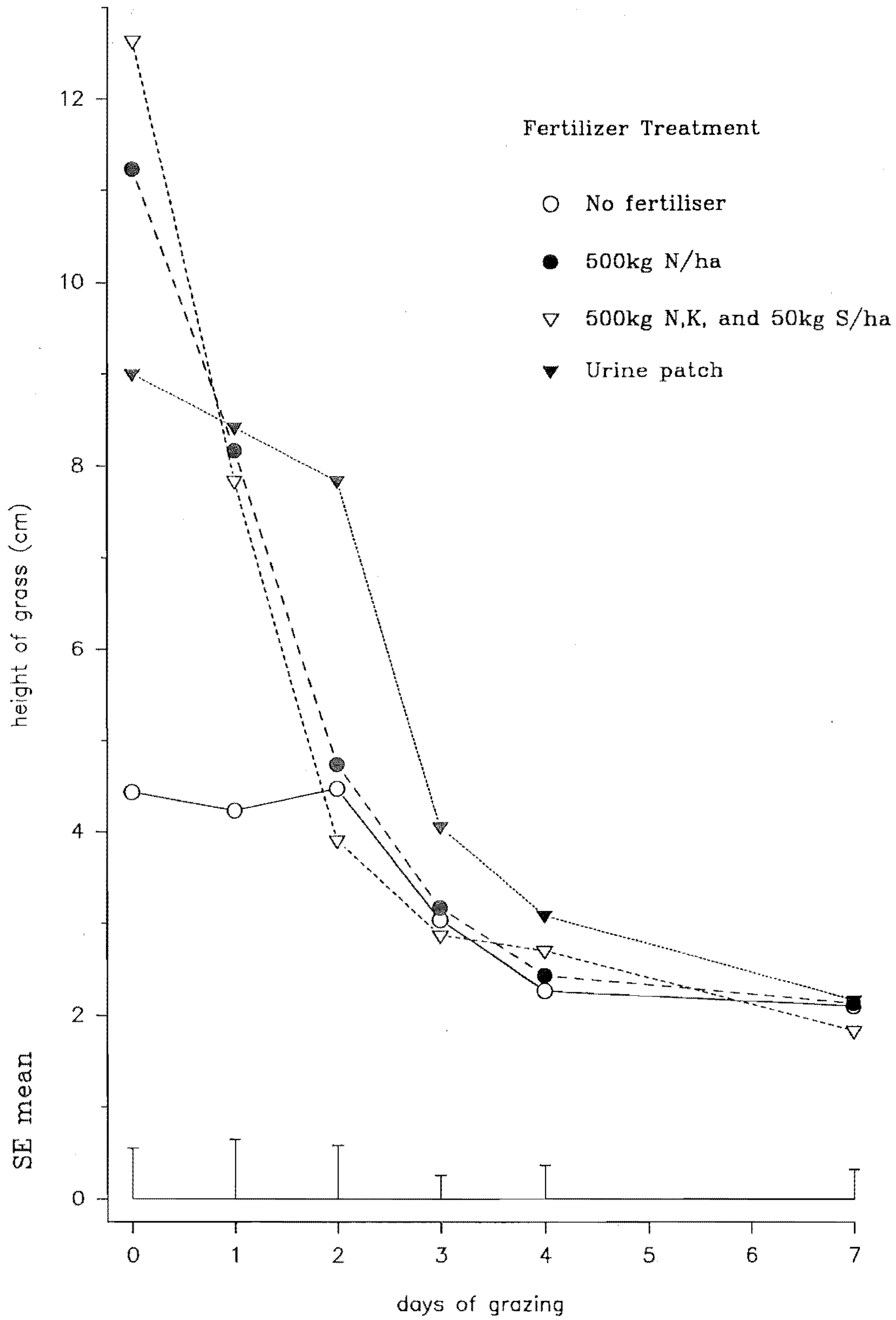

Figure 13. Decline in Phalaris height over the spring grazing period in field trial 3 at Ashley Dene.

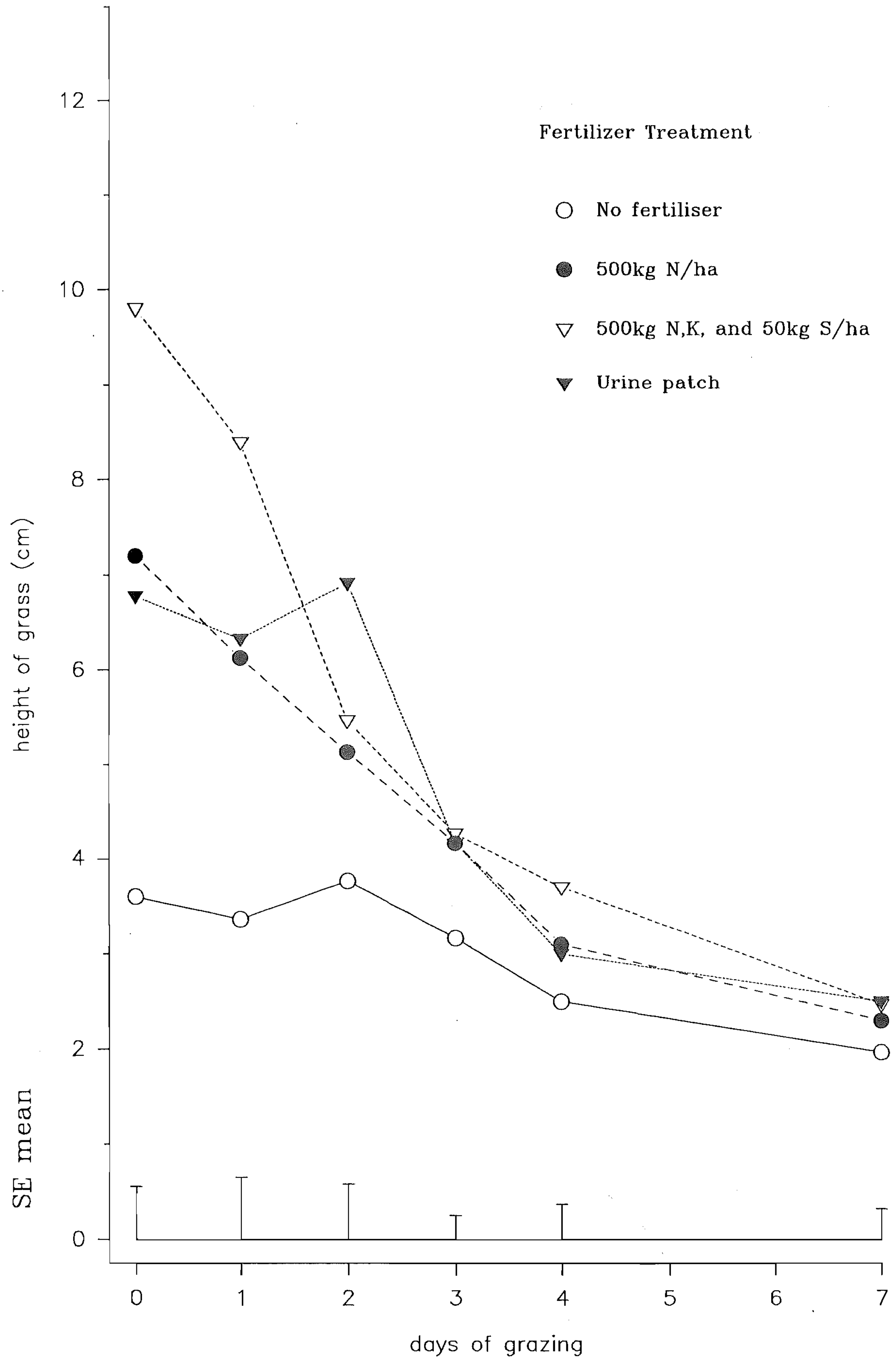

Figure 14. **Decline in Cocksfoot height over the spring grazing period in field trial 3 at Ashley Dene.**

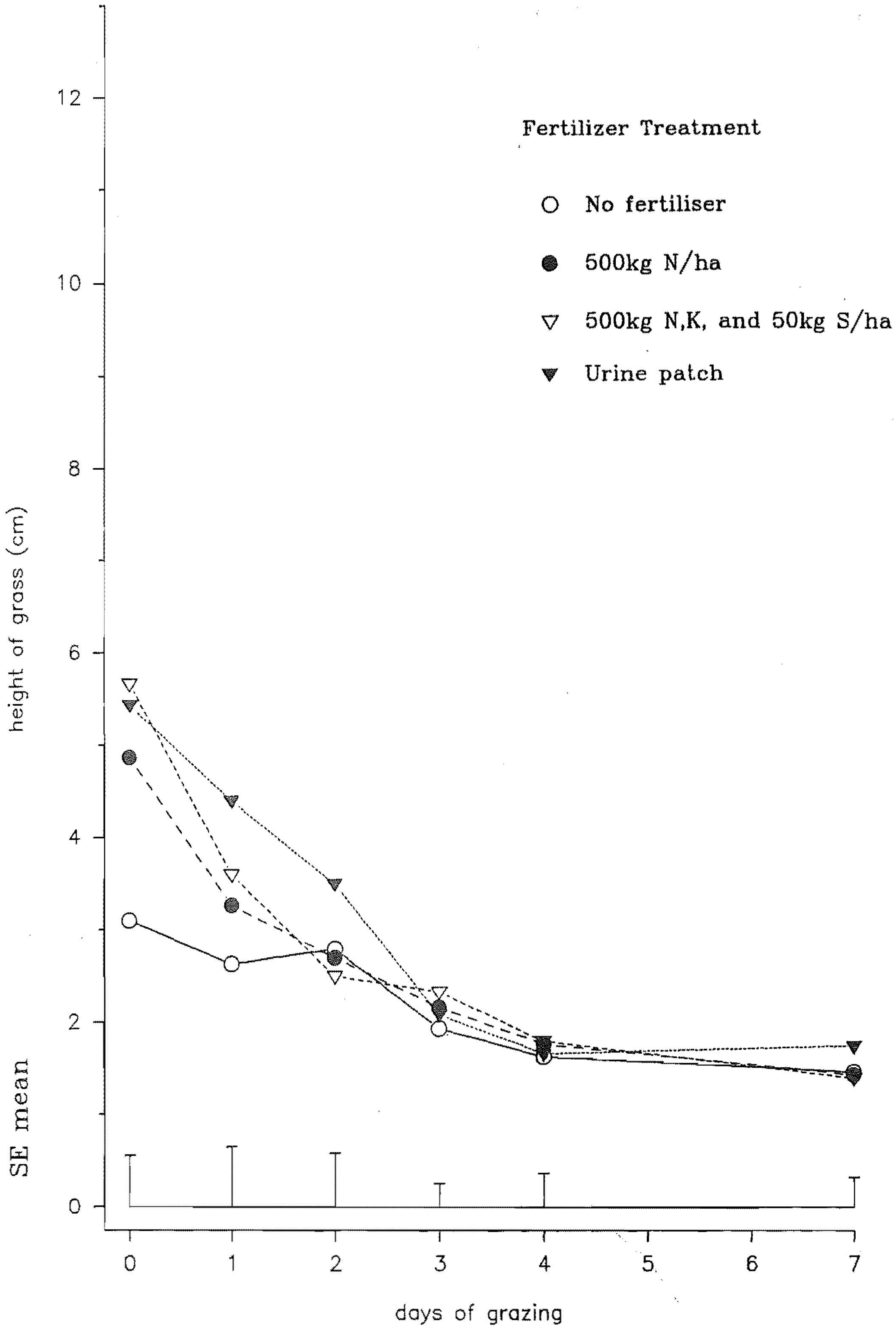

Figure 15. Decline in Yatsyn ryegrass height over the spring grazing period in field trial 3 at Ashley Dene.

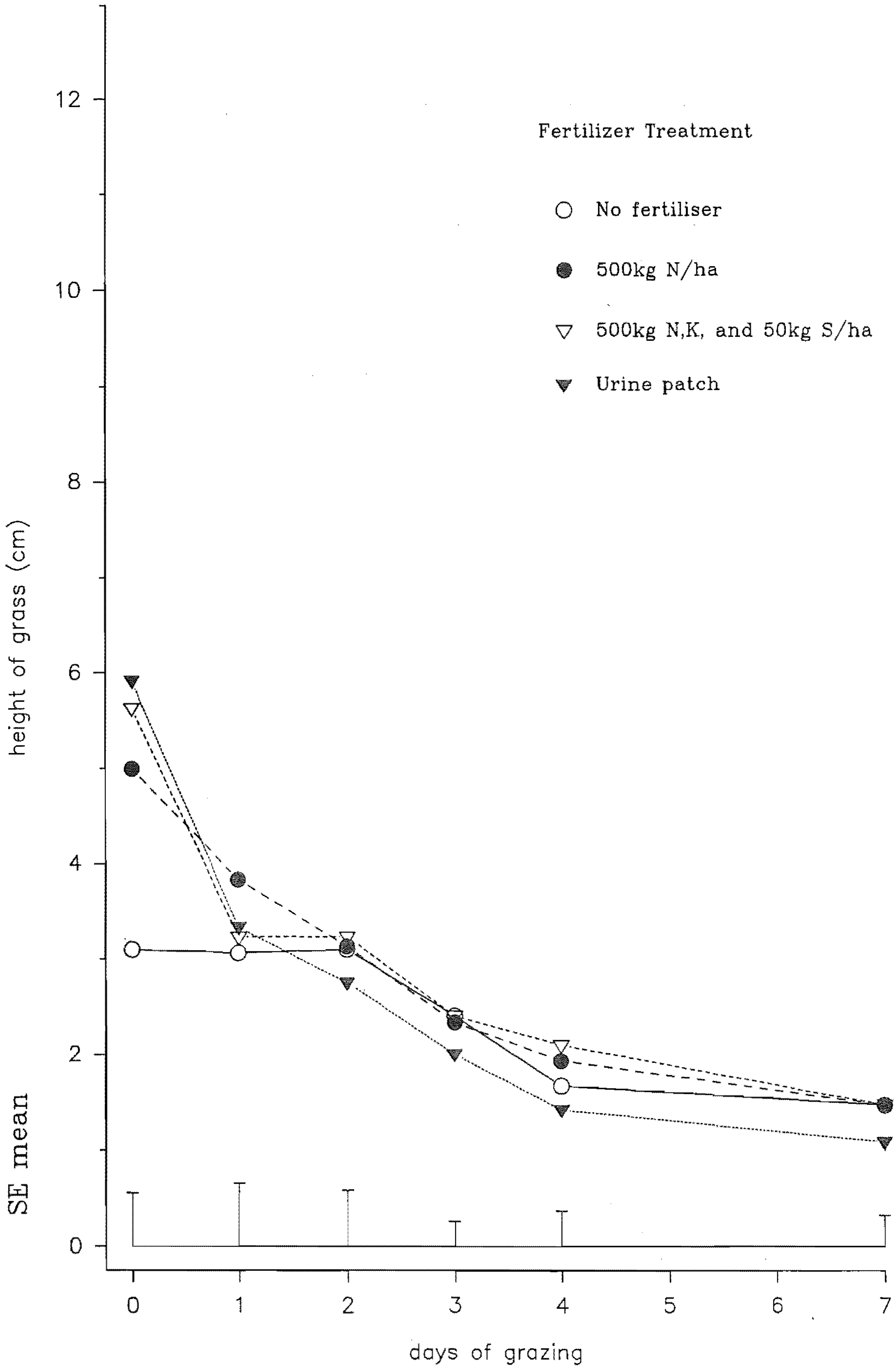

Figure 16. Decline in Fescue height over the spring grazing period in field trial 3 at Ashley Dene.

Table 24: Grass leaf height consumed (cm) by day two, for each species and fertiliser treatment in field trial 3 at Ashley Dene, during spring.

Grass Species	Fertilizer Treatment			
	0	N	NKS	Urine
Phalaris	-0.03	6.50	8.73	1.17
Yatsyn Ryegrass	0.30	2.17	3.17	1.93
Cocksfoot	-1.17	2.07	4.33	-0.14
Fescue	0.00	1.87	2.40	3.17
SEmean	0.82			
CV Percent	60.5			
LSD for the same level of	Grass			2.39
	Fertilizer			2.39

Table 25: Grass leaf height (cm) after seven days grazing, for each species and fertiliser treatment in field trial 3 at Ashley Dene, during spring.

Grass Species	Fertilizer Treatment			
	0	N	NKS	Urine
Phalaris	2.10	2.13	1.83	2.17
Yatsyn Ryegrass	1.47	1.43	1.40	1.75
Cocksfoot	1.97	2.30	2.47	2.50
Fescue	1.47	1.47	1.47	1.08
SEmean	0.32			
CV Percent	30.8			
LSD for the same level of	Grass			0.94
	Fertilizer			1.14

Table 26: Percentage of nitrogen, phosphorous, sulphur and potassium in spring herbage for each species and fertiliser treatment for seventy days regrowth in field trial 3 at Ashley Dene.

Species	Fertiliser treatment	Percentage (%)			
		N	P	S	K
Yatsyn ryegrass	O	3.24	0.30	0.30	3.37
	N	4.02	0.37	0.17	2.53
	NKS	4.56	0.35	0.42	3.75
	Urine	4.11	0.38	0.29	3.46
Phalaris	O	3.72	0.28	0.30	3.59
	N	4.33	0.32	0.26	2.64
	NKS	4.24	0.25	0.24	3.25
	Urine	3.56	0.26	0.29	2.97
Cocksfoot	O	3.64	0.34	0.28	2.67
	N	4.06	0.42	0.22	2.88
	NKS	4.51	0.36	0.36	3.33
	Urine	4.60	0.37	0.33	3.25
Fescue	O	3.57	0.36	0.27	3.21
	N	3.79	0.32	0.22	2.47
	NKS	3.89	0.33	0.27	3.05
	Urine	4.01	0.31	0.24	3.36

CHAPTER FIVE
DISCUSSION

5.1 RATE OF INTAKE TRIALS.

5.1.1 Intake rates.

The fresh forage intake rates of sheep ranged from 13.8 - 25.5 g WM/min and 3.09 - 5.54 g DM/min in rate of intake trial one during autumn; 17.4 - 43.2 g WM/min and 4.87 - 8.90 g DM/min in rate of intake trial two during autumn; and 23.4 - 47.9 g WM/min and 6.36 - 11.02 g DM/min in rate of intake trial three during spring. These intake rates are slightly lower than those reported by Johnson (1992) but higher than those reported by Edwards (1990) and lower than dry-matter intake rates reported for dried forages by Kenney and Black (1984). The reason for the differences is hard to determine. The sheep age, live weight, breed, and experimental methods were similar to Edwards (1990) and Johnson (1992). However variations may have been in type of feed and the degree of satiation of the sheep, which is discussed in section 5.3.1.

5.1.1 Particle length.

Past research on grazing preference has identified particle length or size to be an important variable in determining preference. There appeared to be no relationship between the length of plant material and rate of intake. For example, Marsden ryegrass and phalaris had leaf of similar length, but the wet matter intake rate of phalaris was 1.6 fold higher than that of Marsden ryegrass in rate of intake trial two, or Yatsyn ryegrass with or without application or 50 kg N/ha had leaves of similar length, however the wet matter intake rate of the 50kg

N/ha Yatsyn ryegrass was 25% higher than the unfertilised Yatsyn ryegrass in rate of intake trial three. Further investigation in this area could be done by cutting leaves into shorter lengths to compare with whole leaves.

Colebrook *et. al.* (1985) stated particle length to be a factor influencing the potential rate at which a feed can be eaten. Kenney and Black (1984) and Kenny *et. al.* (1984) in two different experiments showed that reducing the length of forages increases intake rate and preference for the short material. This was considered to be due to reduced time spent chewing shorter material. But their two experiments used only one herbage species. A comparison of rate of intake trials one, two, and three contrasts with Kenney and Black (1984). For example, unfertilised cocksfoot leaf of shorter length in rate of intake trial three, was eaten at a slower rate than the 400 kg N/ha fertilised cocksfoot of longer length. Particle length therefore may not be a very important factor affecting preference for freshly cut pasture leaf when other variables such as the dominant effect of different pasture species or mineral nutrition are present. Age was not compared within either of the trials therefore comments cannot be made on the influences from this factor in these experiments.

In these experiments the influence of pasture species and mineral nutrition appeared to overcome any effects of differing particle size on rate of intake and preference.

5.1.2 Dry-matter percent.

There appeared to be no relationship between dry-matter percent and rate of both wet-matter and dry-matter intake. All the feeds investigated in the three trials were within a few percent of each other with only the odd exception such as nitrogen fertilised phalaris in rate of intake trial one (16%), phalaris in rate of intake trial two (20%) which was lower due to its quicker growth during the late autumn period. As well both unfertilised cocksfoot and Yatsyn ryegrass (28%) were higher and the 400 kg N/ha fertilised Yatsyn (16%) much less than the others in rate of intake trial three. For example, in rate of intake trial three Yatsyn ryegrass which was previously fertilised with 50 kg N/ha was one of the highest in dry-matter percent (23%) and consumed at one of the fastest wet matter rates. Yatsyn which was previously fertilised with 400 kg N/ha was the lowest in dry-matter percent (16%) and was also consumed at one of the fastest wet- matter rates.

Kenney *et. al.* (1984) found that as the DM% of Kikuyu grass (*Pennisetum clandestinum*) fell, the intake rate of wet herbage increased substantially although this increase was not enough to compensate for its decrease in DM%, thus the dry-matter intake declined once the DM% of the feed fell below 40%. John and Ulyatt (1987) concluded that the voluntary consumption of fresh forage is limited by a mechanism regulating intake of wet feed not dry-matter, and that DM% may be an important factor limiting nutrient intake. For example, chicory may be a preferred fresh forage which results in high rates of wet matter intake in sheep, but it may be limiting nutrient intake compared with lower preference forages which have lower wet matter intakes of higher DM% herbage (Johnson, 1992).

5.1.3 Nutrient status.

The plots which received nitrogen fertiliser and were feed in rate of intake trial one were not to be preferred over the unfertilised. But as already mentioned experimental technique varied from other studies and further investigations in this area are needed. In rate of intake trial two the less preferred species, Marsden ryegrass and timothy which were consumed at lower wet matter, were lower in nutrient status. Marsden was lower in nitrogen and phosphorus and timothy lower in sulphur and potassium levels. With rate of intake trial three preference shown for cocksfoot at high nitrogen application rates could be related to the higher nitrogen levels in the plant. This leads to the conclusion that soil fertility and thus nutrient status of the plant may be a very important factor in increasing the voluntary intake of animals and masking species preference.

5.1.4 Species.

Phalaris fresh leaf in rate of intake trial two was consumed at a greater rate than any other species, and for this reason it is was concluded that phalaris is a high preference species for sheep during late autumn. Timothy was the least preferred grass species and wet matter as well as dry matter intake rates were considerable lower.

The results in rate of intake trial two especially conflicted with work of Johnson (1992) but the reason is clearly due to the old age of herbage. The digestible organic matter content which drops as the pasture ages would have been a lot lower in timothy since it ages more quickly compared with phalaris and both lower compared with Johnson (1992). Also, phalaris is winter active with more green leaf present, where as timothy is not a strong winter grower and more active during spring. With rate of intake trial three cocksfoot leaf which was previously fertilised with nitrogen fertiliser was consumed at much higher rate than the unfertilised treatment. The highest fertiliser rate (400 kg N/ha) had the fastest rate of intake. Therefore, it can be concluded that fertilisation can mask preference for cocksfoot.

In contrast wet matter intake of Yatsyn ryegrass showed no real relationship with the fertiliser treatments. However, on a dry matter basis, the rate of intake decreased with the increasing fertiliser rate. This decrease could be related to an increase in endophyte with increasing fertiliser application. It is commonly known that high nitrogen fertilised ryegrass or ryegrass urine patches are high in endophyte. Even though endophyte levels are low during spring, ryegrass endophyte hyphae concentrations were infact double at higher nitrogen levels (Lucas, pers. comm.). Keogh (1984) demonstrated this but found sheep to prefer the urine patches even though concentrations of endophyte were high. Therefore, the endophyte may not be the dominant effect influencing Yatsyn ryegrass rate of intake.

However, Kenney *et.al.* (1984) related preference for dried forage to the rate at which it can be eaten but at present not relationships have been published which directly relates intake rates of fresh or wet matter to preference.

5.2 FIELD GRAZING TRIALS.

5.2.1 Pasture mass.

The initial pasture mass of all the unfertilised species in field trial one during autumn, except phalaris and Yatsyn ryegrass were significantly different. Initial pasture mass had no influence on the rate of decline in height between species. Phalaris and Yatsyn ryegrass were both of similar pasture mass but phalaris was reduced by 4.25cm whereas Yatsyn ryegrass was reduced only by 1.40cm after two days grazing (table 14). In field trial two during autumn, similar results occurred with unfertilised phalaris and timothy which both had similar initial pasture mass, but phalaris being reduced by 6.83cm and timothy by 1.58cm after two days grazing (table 19). In field trial three during early spring initial pasture mass varied slightly between the unfertilised species and there was very little reduction in height after two days grazing.

Hodgson (1982) stated that variations in sward conditions are expected to exert direct effects upon intake per bite and rate of biting. Therefore, if all other variables were equal, animals would graze sites of high pasture mass in preference to sites of low pasture mass as the potential rate of intake would be higher. In the three field trials this does not appear to be the case as the effect of differing sheep preferences for pasture species has over ridden any effect of pasture mass. Alternatively pasture masses may not have been different enough, between species, except fescue in field trial one, for animals to discriminate for or against high or low mass species. Fescue pasture mass in field trial one was extremely low at 300 kg DM/ha, but the others only ranged from 500 to 800 kg DM/ha. Pasture mass in field trial two ranged from 2050 to 2450 kg DM/ha and in field trial three ranged from 500 to 800 kg DM/ha.

The pasture mass of plots that received fertiliser were between two and three times higher than unfertilised plots (except the potassium/sulphur plots in field trial 2). The fertilised pasture mass ranged from 750 to 1400 kg DM/ha in field trial one and 850 to 1600 kg DM/ha in field trial two. However, again the pasture mass did not appear to influence the decline in height between species and fertiliser treatments. For example, the fertilised phalaris in field trial one, even though higher in initial pasture mass, wasn't reduced at a faster rate than the lower mass unfertilised phalaris.

5.2.2 Pasture height.

In field trial one phalaris and Yatsyn ryegrass which was previously fertilised with either nitrogen or nitrogen/potassium/sulphur were different in initial height but the rates of decline in height for the two species were similar (figure 2-4). In field trial two similar results occurred with the nitrogen and nitrogen/potassium/sulphur fertilised phalaris and mountain brome. For example, nitrogen fertilised phalaris and mountain brome initial heights were 16.8 and 11.5 cm. Also, unfertilised phalaris and cocksfoot were very similar in initial height but phalaris declined at a much greater rate over the first three days of the trial period (figure 6-7). Similar results to field trial one were obtained in field trial three with cocksfoot and Yatsyn ryegrass (figure 14-15). Therefore, it can be concluded from this that the sheep did not initially graze in preference for swards of higher initial heights but as the grazing period progressed less preferred species were grazed because they had more leaf than the preferred species which had already been eaten down to low levels leaving only pseudostem.

As with pasture mass the fertilised plots (except the potassium/sulphur plots) approximately had double the initial pasture heights of unfertilised plots and apart from the initial preference in the first day or two were not reduced in height at a faster rate. Initial pasture height however is not considered to be the factor influencing the rate of decline as there was no relationship between height and rate of decline with the fertiliser treatments. It is conceivable however, that taller swards would be preferred over shorter swards of the same species. Clark *et. al.* (1982) found that cattle, sheep and goats offered perennial ryegrass of differing heights all preferred to graze taller swards.

Sward height may influence preference but it is conceivable that many other factors such as stage of maturity and species, would have a more significant effect.

5.2.3 Nutrient status.

Sheep showed no obvious preference for plots that had earlier received fertiliser in field trial one. For example, phalaris clearly demonstrated no difference between fertiliser treatments as all treatments had similar rates in decline (figure 2). This was generally the same for all species with rate of decline differences only occurring in the first day or two.

In field trial two there appeared to be an initial preference for nitrogen and nitrogen/potassium/sulphur fertiliser plots as leaf heights were dramatically reduced in the first day, but there after rate of decline was similar between treatments. Also, distinct differences between the unfertilised or potassium/sulphur fertilised plots and the nitrogen or nitrogen/potassium/sulphur plots were apparent, even though rate of decline was similar (figure 6-12).

With field trial three some preference was more obvious for the nitrogen or nitrogen/potassium/sulphur fertilised plots even though nitrogen content was generally lower than autumn field trial one. This was demonstrated by the rapid rate of decline within the first two or three days (figure 13-16). The additional treatment of a real urine patch also demonstrated the obvious preference but the height was not reduced very much until day three for all the species. This slow initial grazing may be related to the small urine patch diameters compared with the larger fertiliser plots and therefore maybe sheep did not find the patches immediately.

The rates of fertiliser used were believed to represent the approximate concentration of a urine patch. These grazing preferences for high nitrogen, potassium and sulphur pasture as well as the real urine patches in field trial three support the findings of Keogh (1986), Edwards (1990) and Johnson (1992), who all reported that stock selected urine patches and high nitrogen plots in preference to inter-urine patches and non-nitrogen plots. Under continuous stocking this was expressed as a higher intensity and greater frequency of defoliation of urine patches (Keogh, 1986). In general the unfertilised grasses were lower in nitrogen, potassium, and sulphur content than the nitrogen/potassium/sulphur fertilised grasses in field trial three, which may have contributed to their initial rejection by sheep. However, determining species preferences due to nutrient content was not as clear cut. For instance, phalaris was preferred in all three field trials but in some cases certain nutrients were low. For example, phalaris had one of the lowest phosphorous contents in trials one and three (table 15). This leads to the conclusion that soil fertility and thus nutrient status may only be important for some species. Therefore, the negative effect on preference of certain lower nutrient contents, may not be great enough to overcome the positive effect of desirable plant species on sheep preference.

5.2.4 Pseudostem.

There appeared to be a definite pseudostem barrier within the swards in field trial one except for one species, Yatsyn ryegrass. The psuedostem of Yatsyn ryegrass was reduced over the autumn grazing period especially when fertilised. This result contrasts with Johnson (1992) who found Yatsyn ryegrass not to be grazed beyond the pseudostem height. Also Barthram (1980) and L'Huillier *et. al.* (1984), also found ryegrass pseudostem not to be a preferred sward component and that it is often rejected. Edwards (1990) also had similar results with high endophyte in Nui ryegrass.

However, it must be noted that phalaris had a considerable amount of residual dead material and stem stubble which may have prevented sheep from grazing down to pseudostem heights. It is a well known factor that animals select against dead material (Barthram and Grant, 1984; Arnold, 1981).

In field trial two all of the fertilised species pseudostem heights except the potassium/sulphur plots were considerably reduced over the grazing period. Therefore, one can conclude that fertiliser may improve the palatability of pseudostems of some species.

Edwards (1990) suggested the height of the pseudostem may influence the height at which a sheep prefers to graze. This may be true in a pure species sward, but in a situation where there is a range of pasture species on offer other aspects of preference such as species preferences and nutritional status may become more important than pseudostem height.

Edwards (1990) also suggested that where sheep were forced to graze pseudostem, that pseudostem diameter is likely to influence bite depth and thus bite size. Pseudostem size did not appear to influence the preference of sheep in these trials as cocksfoot with a larger pseudostem was not significantly reduced any more than Marsden ryegrass in field trial two. Pseudostem size may however have an influence on preference within swards of pure pasture species (Johnson, 1992).

Ease of prehension did not appear to be a major factor controlling the preference of sheep between the plant species and fertiliser treatment.

However, these results were not very clear cut and more intensive sampling would have given more precise results.

5.2.5 Species.

Phalaris was the preferred species out of the four investigated in field trial one. This species was reduced in height at a fast rate and reduced to a low residual height. This result agrees with Johnson (1992) who found phalaris to be desirable and selected by sheep. With field trial two there appeared to be more than one preferred species out of the six species investigated. Phalaris was again reduced in height at the fastest rate in the first few days but was not significantly different from fescue, timothy/Marsden ryegrass mixture and Marsden ryegrass. In field trial three there was no preferred species. However, after fertilisation phalaris was clearly preferred and reduced in height at the fastest rate with cocksfoot also being reduced severely. Thus, after fertilisation preference seems to be masked with less preferred species such as cocksfoot in field trial three. It was also suggested that presence of legumes in the plots at Ashley Dene due to the autumn season being more moist, may have reduced the ability of sheep to discriminate between species and treatments in field trial one and three.

These results do not agree totally with findings (unpublished) from field trials carried out on these species at "Ashley Dene" over the last four years. As well as phalaris, fescue was found to be preferred by sheep over cocksfoot and Yatsyn ryegrass (Lucas, pers. comm.). Both Edwards (1990), and Johnson (1992) also found fescue to be preferred. But it must be noted that fescue was considerably lower in pasture mass and height, and contained other species such as vulpia hair grass (*Vulpia bromoides* L.). Also fescue plots this year contained a lot more reproductive tillers as it went to seed last year.

Observations were also noted with other species in field trial one. Chicory, white clover, and weed species like dandelion (*Taraxacum officinale*) were actively selected during the first day (plate 11). It is concluded from this that sheep have a very high preference for these dicotyledon species, above that of high producing grass species.

Plate 11: Grazing preference of sheep for weeds in headlands outside plots one day after sheep entered field trial 1.

5.3 DISCUSSION OF METHODS USED.

5.3.1 Rate of intake trials.

The amount of feed offered prior to, and during a rate of intake trial may influence the results of the experiment.

For all the three trials animals were given their usual nightly feed (6kg fresh) and then denied access to feed until the trial commenced early the next day. The non significant result from rate of intake trial one may have been due to not being given a light midday feed (3kg fresh) between the experimental feeds which was carried out for rate of intake trial two and three.

By denying animals feed prior to the commencement of the trials the results may have not realistically indicated the animals preference due to the fact that they were very hungry and willing to ingest anything. However, there is a dilemma as if animals are not denied access to feed they may not be hungry enough to eat the whole meal without stopping.

Due to limitations in collecting an adequate amount of herbage, feed samples were no greater than 50 grams. The offering of only 50 grams per treatment may have also influenced the results. A small feed produces greater start and end errors, and may benefit the less preferred species because the animals drive for satiation may be stronger than their preference. Also, a smaller sample feed meant that the sheep received only approximately 700 grams dry matter in total for the day in trial two for example. This is considerably below their feeding capacity (1.2 kg DM/day), thus it is quite likely that the animals were hungry. Johnson (1992) fed 100 gram samples in a similar trial, although a midday feed was not offered. This trial encountered problems with sheep leaving feed residuals. This brings in another problem of identification of the point in time that animals have finished eating their meal as a lot of time could be spent by the animals consuming the last small portion of the meal. Therefore, an intermediate feed sample between 50-100 grams could be more suitable. As well a problem with the fed containers used in rate of intake trials is sheep find it difficult towards the end to easily get leaf off the smooth plastic and corners of the container.

A more accurate method for measuring rates of intake may be to offer pre-weighed cut feeds for a length of time and measure the amount of feed eaten over the time period (Johnson, 1992). This would reduce some of the problems outlined above. This method has been used by other researchers for calculating dry matter intakes of forages, with good results (Kenney and Black, 1984). But it involves the messy procedure of having to collect saliva covered residual material, which is difficult to determine fresh matter intakes.

Rate of intake trials are not the most quick and easiest of methods to determine preference. For example, sheep have to be trained and calmed for at least a week before a trial can proceed. Also, their reliability is in question and more work on techniques relative to sheep appetite is required. Although, no definite relationships have been published relating fresh-matter intake rates to grazing preference and ultimately grazing intake it is still useful information when investigating the preference of animals for different plant material.

5.3.2 Field trials.

Field trial pasture height measurements are a quick (approx. one hour per day) and easy method of obtaining preference between species and fertiliser treatments. An advantage of this method clearly is that species are growing in their natural state and have not been manipulated as in rate of intake of cut material. Therefore, preferences exhibited are what would happen in the normal grazing of pasture.

An alternative method would be to observe and count the amount to animals grazing on the plots of each pasture species and fertiliser treatment, so long as plots were pure species and large enough. Edwards (1990) used this technique with good results. If this technique was performed on bigger plots in these trials problems could have occurred with animals being disturbed while trying to observe, due to the experimental design. The use of an observation tower (Edwards, 1990), or photographic techniques (Hunt and Hay, 1990) would have enabled better observation without disturbing the animals.

CHAPTER SIX

GENERAL DISCUSSION AND CONCLUSIONS.

6.1 DISCUSSION.

Comparing the results from the rate of intake trials with field trial results shows limited correlation.

In field trials unfertilised and fertilised phalaris was reduced in height at a rapid rate which suggested that it was being actively selected for by sheep. The rate of intake of phalaris wet matter in rate of intake trial two was also the highest compared with other grass species which backs up field measurements and leads to the conclusion that phalaris is a preferred species by sheep during late autumn and early spring. Johnson (1992) also found that sheep actively selected phalaris. This contradicts the previous reputation of phalaris for being a species of low palatability (Langer, 1990).

Unfertilised cocksfoot in field trial one was also reduced in height but not quite as rapidly as phalaris which also suggests that is was being actively selected. But in field trial two only the nitrogen, and nitrogen/potassium/sulphur fertilised cocksfoot as well as the fertilised cocksfoot in field trial three were reduced in height rapidly. In rate of intake trial two a similar result to field trial one occurred with cocksfoot fresh leaf material being consumed at a considerably high rate. Even though these results correlate well, which leads to the conclusion that cocksfoot is a preferred species by sheep, it is not valid to compare grass from different sites. However, this cocksfoot result does not agree with Johnson (1992) who found cocksfoot to be rejected by sheep. The results in field trial two and three as well as the rate of intake trial three leads also to the conclusion that cocksfoot is preferred over other species when fertilised.

Yatsyn and Marsden ryegrass were both included in rate of intake trials and field trials. In field trials both unfertilised and fertilised Yatsyn and Marsden ryegrass were reduced at similar rates as with cocksfoot. Unfortunately with the non significant result in rate of intake trial one Yatsyn measured in the field cannot be compared with measurements in intake trials. With unfertilised Marsden ryegrass in rate of intake trial two, fresh leaf material was eaten at a substantially slower rate compared with phalaris or cocksfoot. Therefore, poor correlation between field and rate of intake trial two occurred. The result in rate of intake trial two does however agree with Edwards (1990) and Johnson (1992) who proposed lower animal production would result from animals grazing +E ryegrass. The rate of intake trial three also did not correlate well with a field trial conducted using similar treatments at Ashley Dene (Nolan, pers. comm.). However, herbage offered in rate of intake trial three had previously more severe grazing by sheep and subsequently had less dead material present.

Fescue has been shown to be a preferred species by sheep (Edwards, 1990; Johnson, 1992). In field trials one and three initial fescue height was very low, which meant height reductions were only slight, and thus preference for that species was not really measured. Field trial two however showed fescue to be only moderately reduced in height and this was backed up with rate of intake trial two where fescue was eaten more slowly than cocksfoot and phalaris.

Unfertilised mountain brome was included in both rate of intake trial two and field trial two. The rate of intake of unfertilised mountain brome was as high as unfertilised cocksfoot but in field trials, cocksfoot was reduced in height at a slower rate. Therefore, with this unfertilised grass species, field trials were not backed up with rate of intake trials. Unfortunately fertilised mountain brome was not measured in the rate of intake trials so comparisons and comments could not be made.

Unfertilised timothy was included in both rate of intake trial two and field trial two. In both the field trial and rate of intake trial unfertilised timothy was less preferred. Again fertilised timothy was not measured in the rate of intake trial so comparisons and comments could not be made.

Finally no differential grazing was observed with the timothy/Marsden ryegrass mixture in field trial two and was not present in rate of intake trial two, so comments can not be made.

Thus, preference of sheep for pasture is influenced by many factors such as fertility status of the soil and subsequent nutrient status of the plant, and the range of plant species on offer. The preference ranking of species reported in this dissertation is for a particular type of plant material in particular seasons. Therefore, if this type of information is to be put into practice many factors have to be considered. Understanding species preferences by sheep may enable animal growth rates to increase as well as decrease the total feed maintenance costs and increase farm efficiency.

6.2 FUTURE WORK REQUIRED.

From the results of this investigation future work is suggested in the following areas:

1) Field trials similar to those carried out in this experiment but at more times throughout the year to determine the affects of the four differing seasons on the preference ranking of pasture species by sheep.

2) Modification of the above method would be to devise a method so that animals can be accurately observed to give an indication of preference without disturbance to grazing.

3) Modification of the rate of intake trials, would be to devise a more accurate method of measuring intake rates such as offering pre weighed cut feeds for a length of time and measuring the amount of feed eaten over the time period. Also ideally this would be preformed over both morning and afternoon and for a time period longer than one day, such as three days.

4) Further experiments should be undertaken to support suggestions from these trials that the fertility of the soil and thus nutrient content of the plant material overcomes any differences between some species. For example:-
Experiments could include growing grasses in boxes with different fertilities and times of regrowth to create herbage with a range of dry matter percent and nitrogen percent. It could also include manipulating leaf heights and pasture densities by cutting. Boxes then weighed and offered to sheep to get dry matter intake rate as well as height decline

6.3 CONCLUSIONS.

1) In the rate of intake experiments the influence of pasture species and mineral nutrition appeared to overcome any effects of differing particle size on rate of intake and preference.

2) Sheep did not demonstrate in all trials preference for herbage high in nutrient content when offered the option of sites where no fertiliser and fertiliser had earlier been applied. Therefore, not in all cases will high nutrient content levels overcome differences in preference between species.

3) The preference of sheep for pasture species and treatments demonstrated in field trials did not in all cases show close correlation to rate of intake of cut fresh herbage.

4) Sheep show high preference for phalaris as shown by high rates of fresh matter intake and a rapid reduction in height in field trials.

5) Timothy was shown to be of low preference in one of the rate of intake trials.

6) Rate of wet and dry matter intake of cocksfoot increases with increasing nitrogen percent in leaf.

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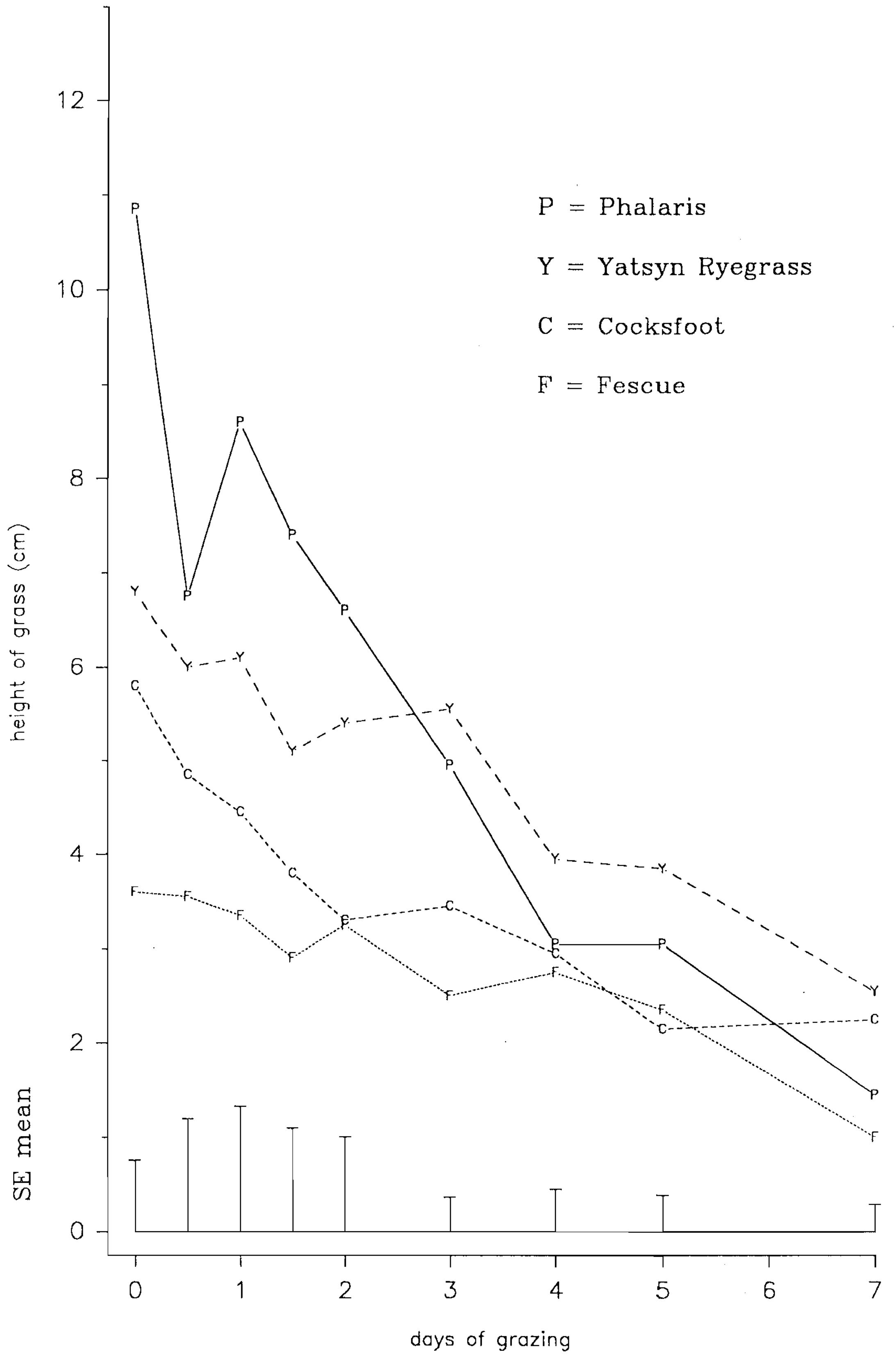
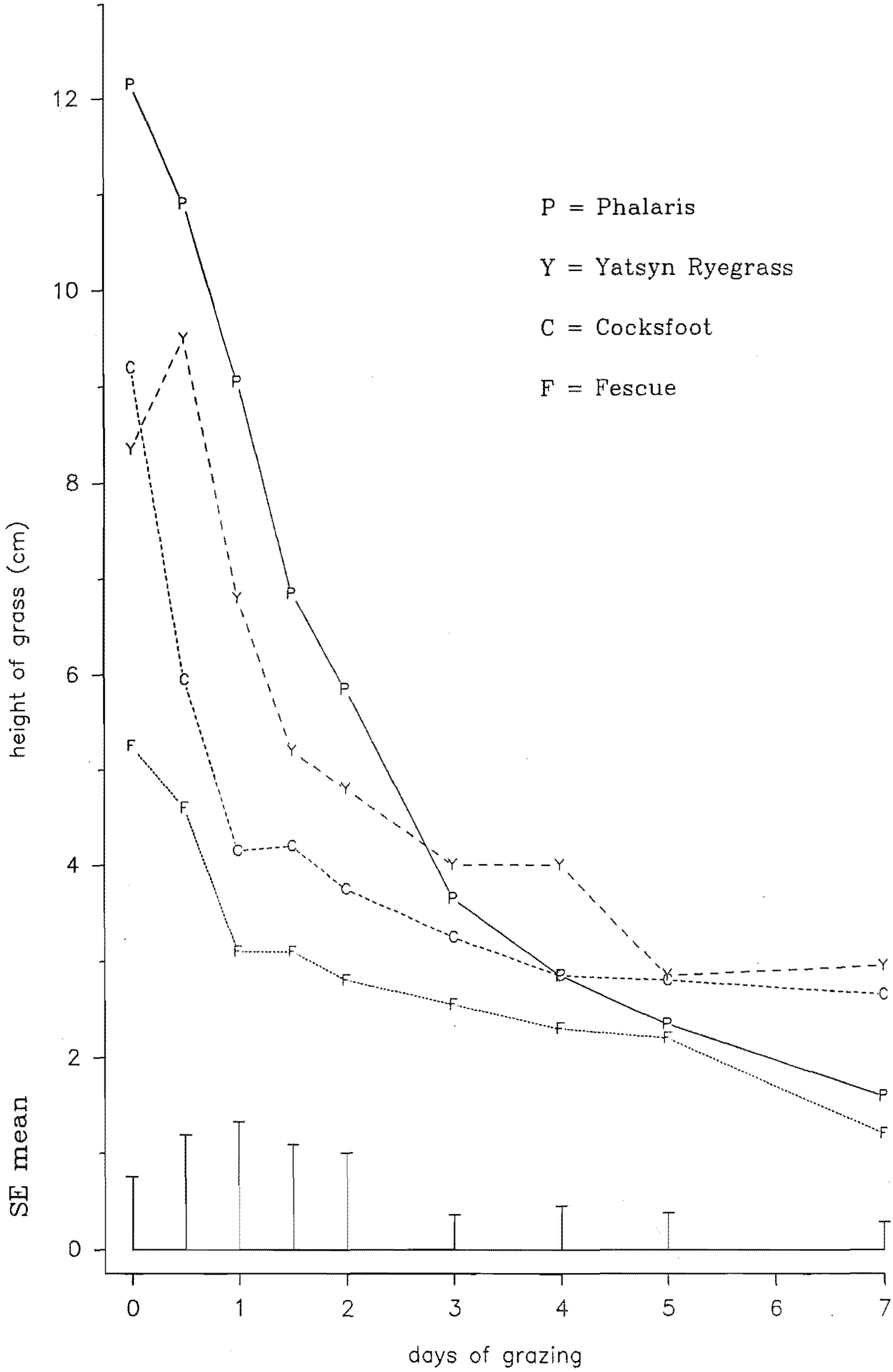
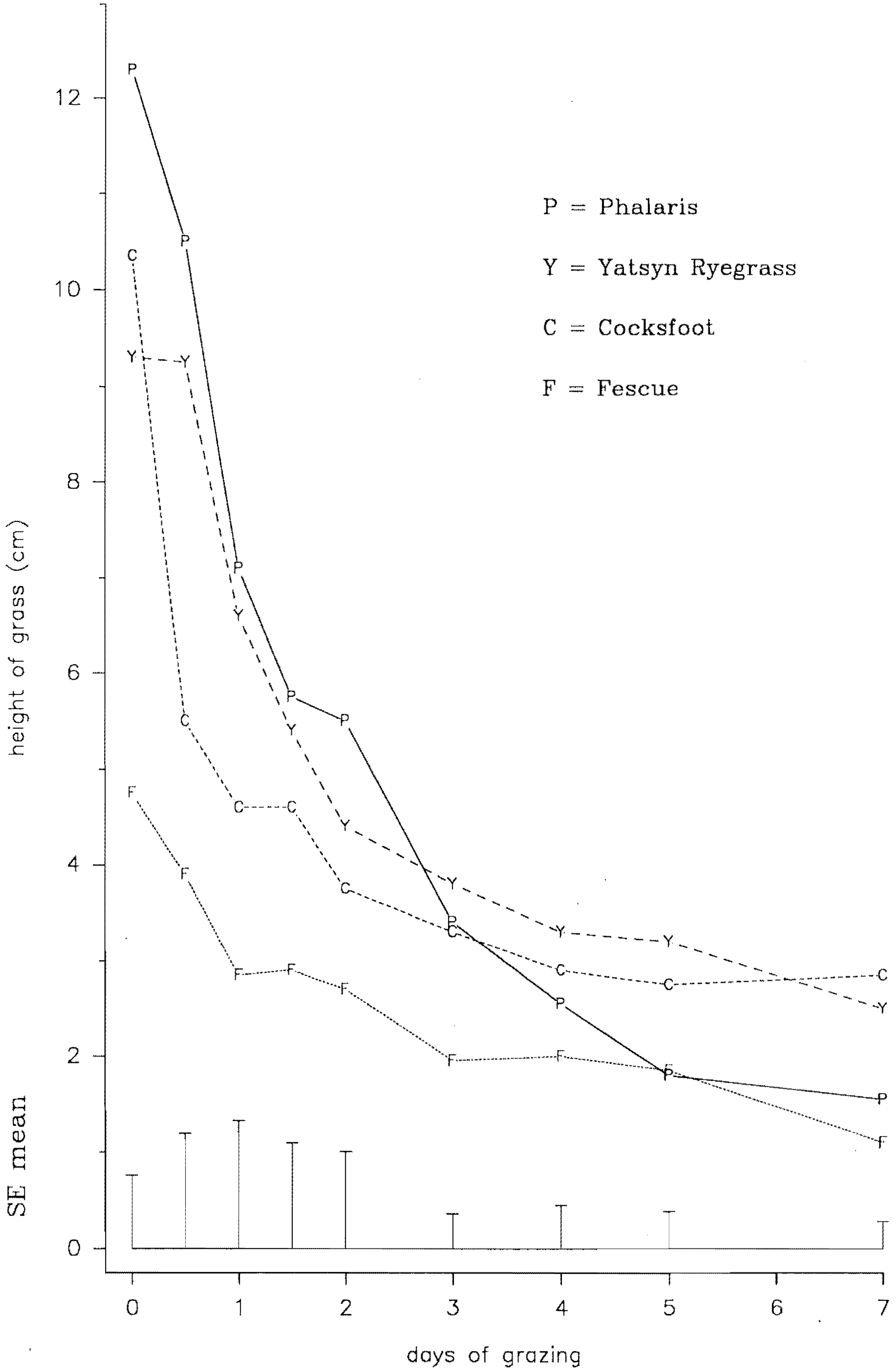


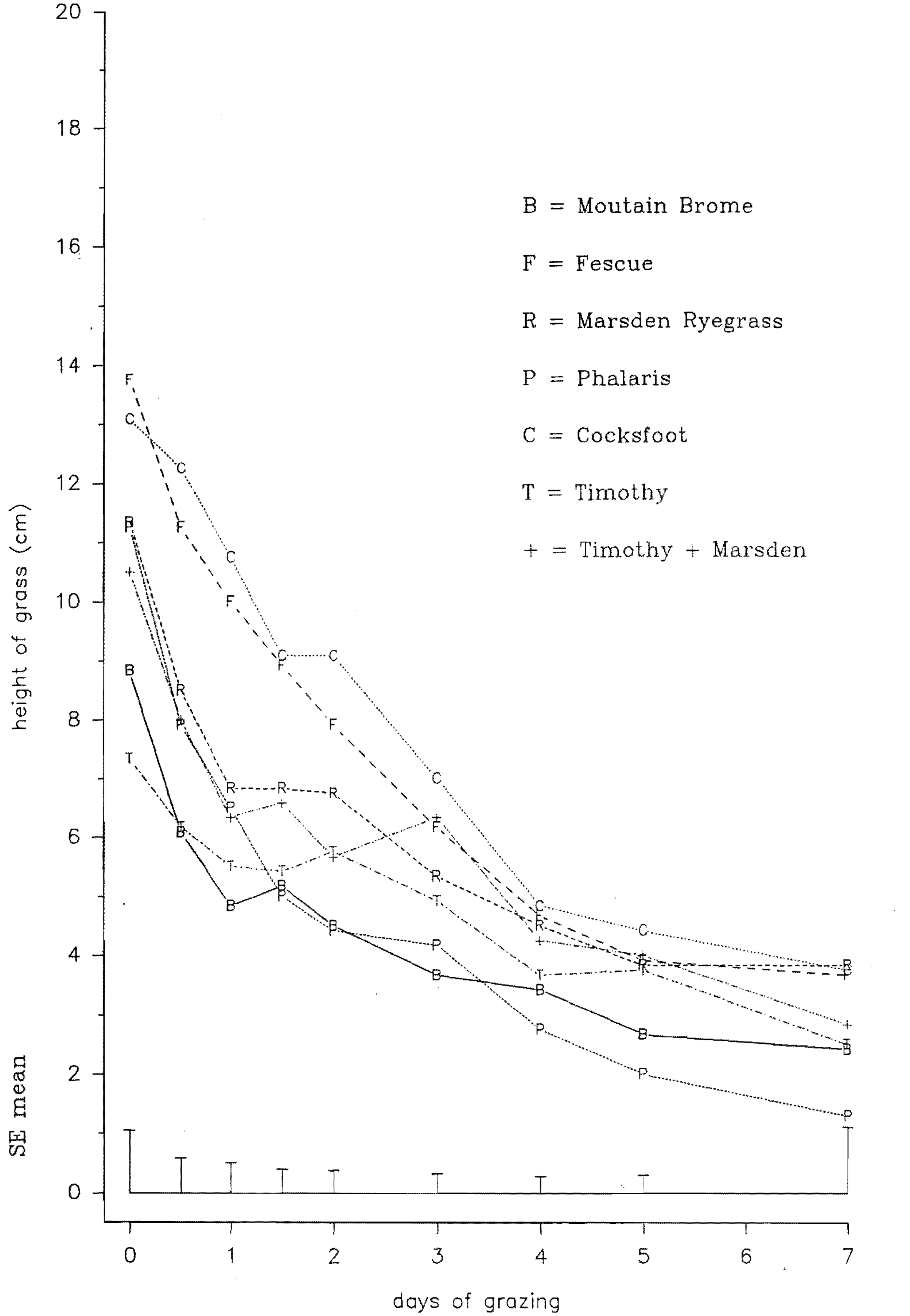
Appendix 1. Decline in grass heights with no fertiliser over the autumn grazing period in field trial 1 at Ashley Dene.



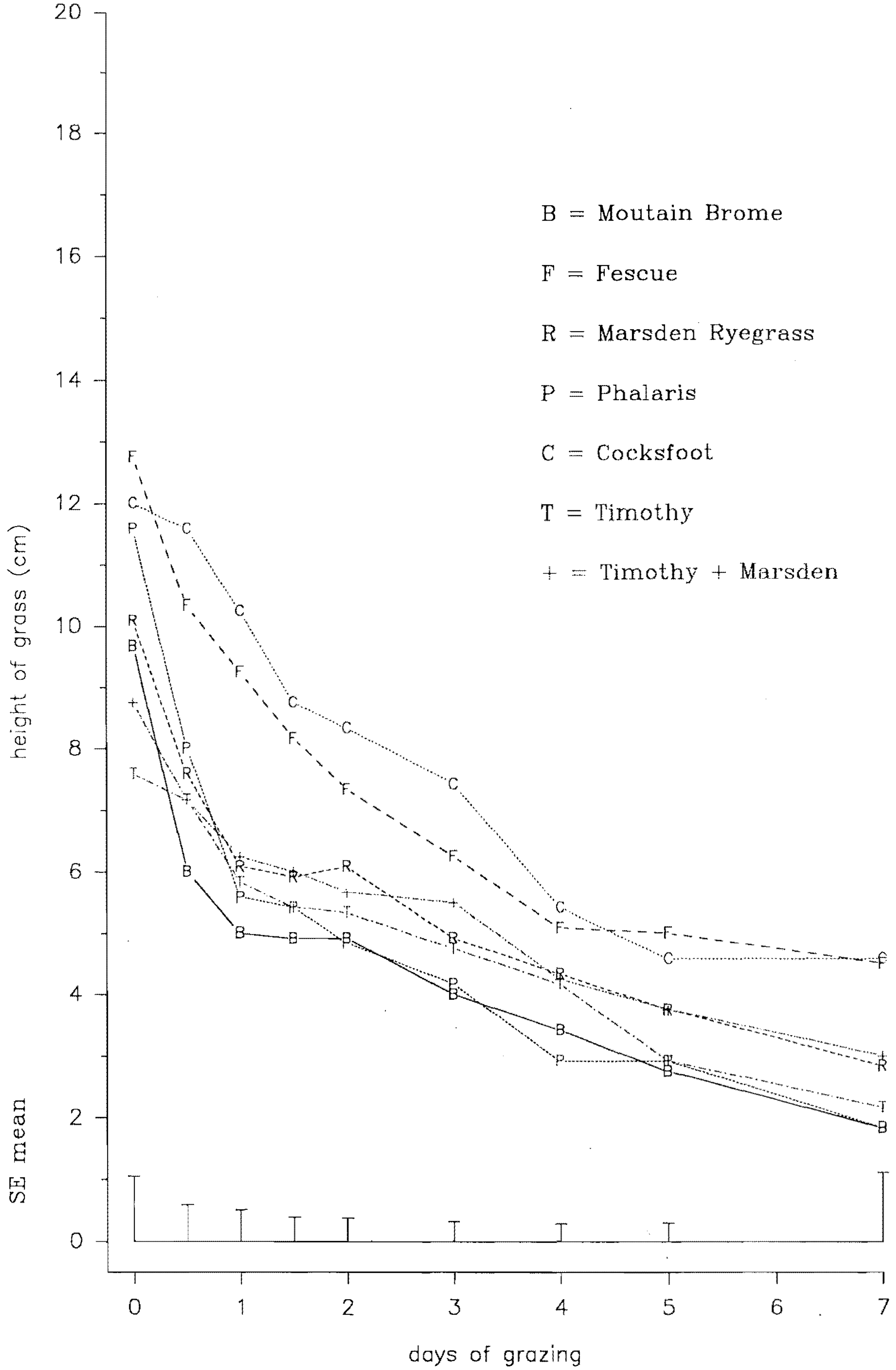
Appendix 2. Decline in grass heights with nitrogen fertiliser over the autumn grazing period in field trial 1 at Ashley Dene.



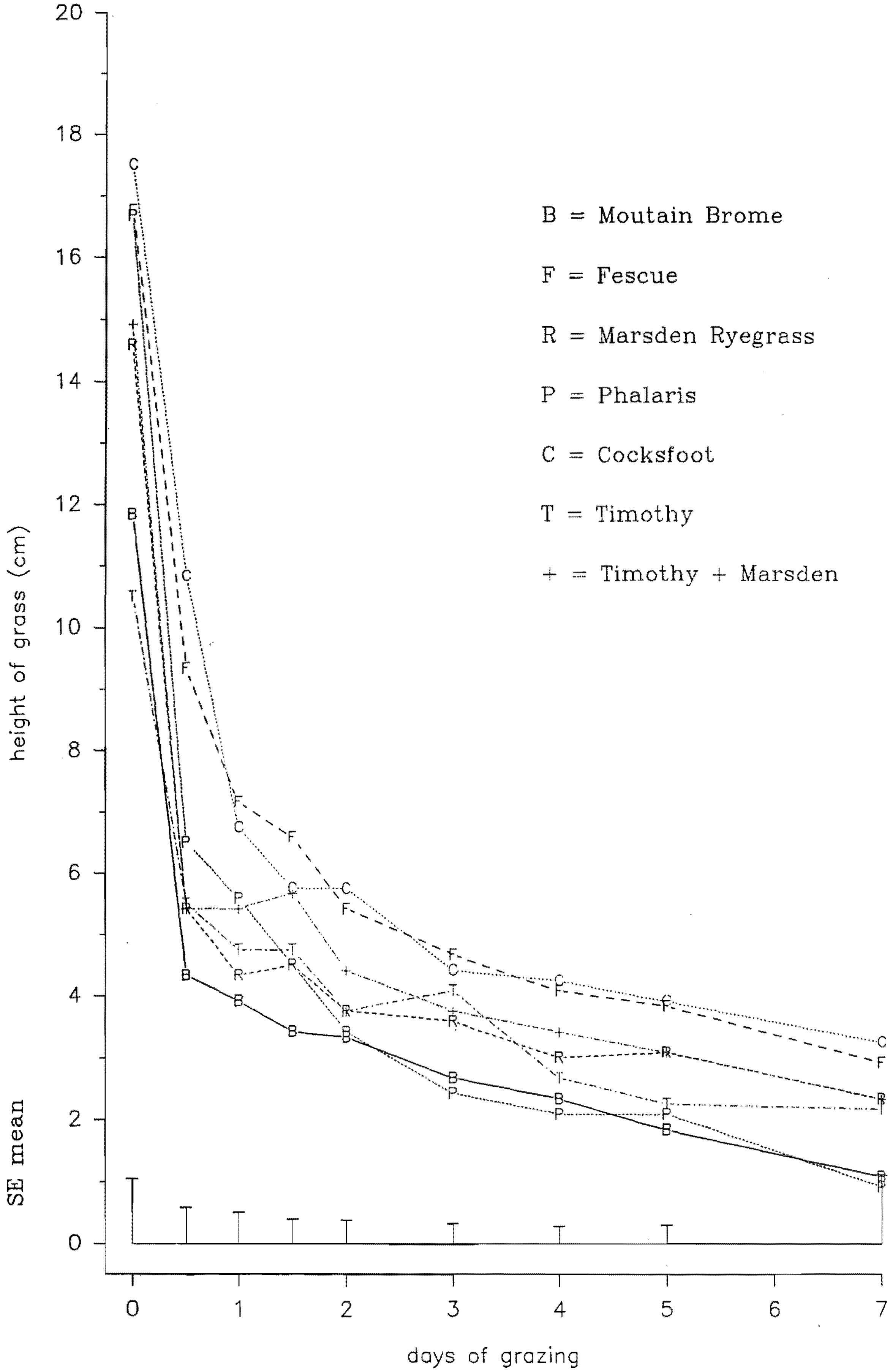
Appendix 3. Decline in grass heights with nitrogen/potassium/sulphur fertiliser over the autumn grazing period in field trial 1 at Ashley Dene.



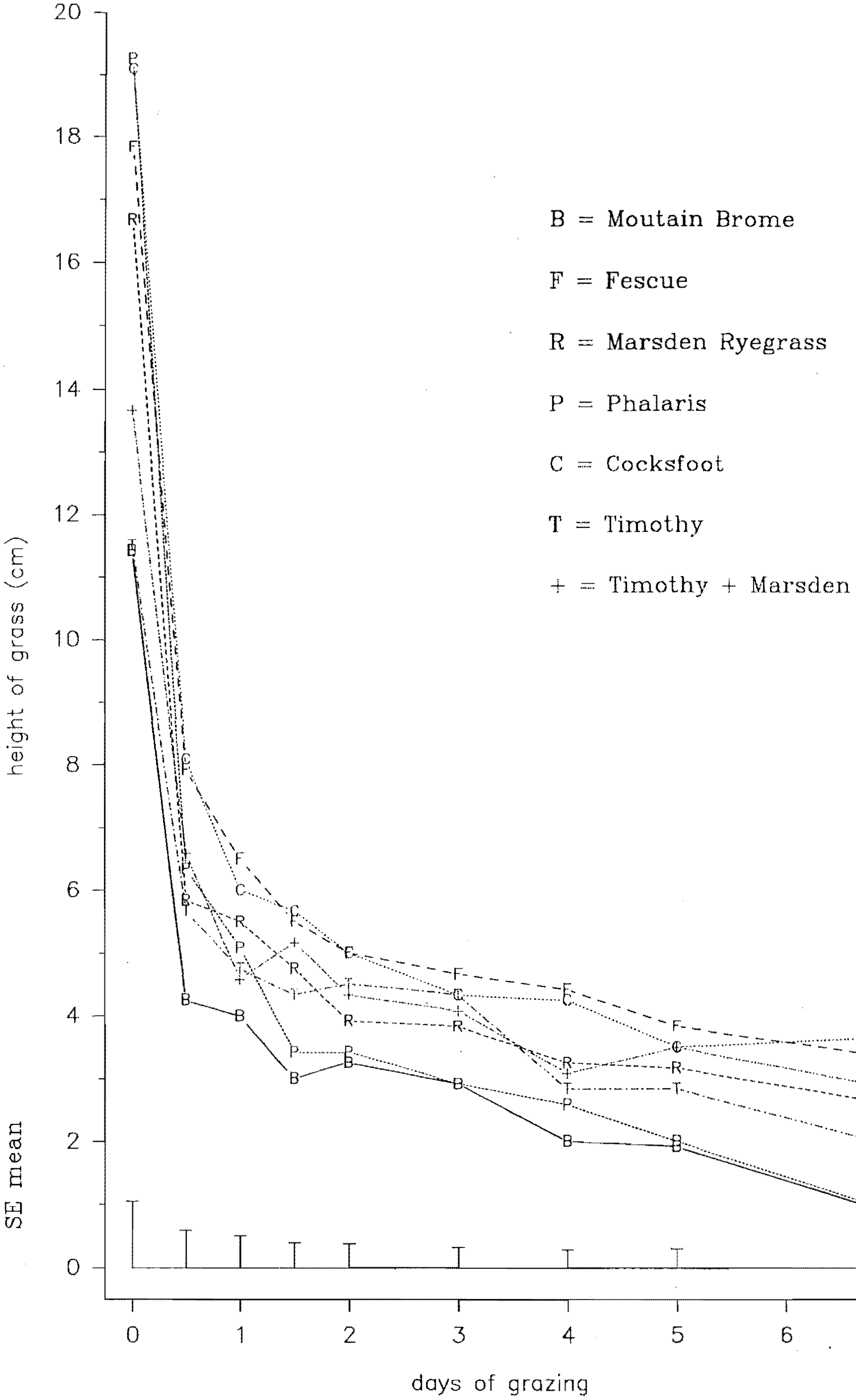
Appendix 4. Decline in grass heights with no fertiliser over the autumn grazing period in field trial 2 at Iversen Field.



Appendix 5. Decline in grass heights with potassium/sulphur fertiliser over the autumn grazing period in field trial 2 at Iversen Field.



Appendix 6. Decline in grass heights with nitrogen fertiliser over the autumn grazing period in field trial 2 at Iversen Field.



Appendix 7. Decline in grass heights with nitrogen/potassiuum/sulphur fertiliser over the autumn grazing period in field trial 2 at Iversen Field.