
HERBAGE PRODUCTION BY RYEGRASS, TALL FESCUE AND PHALARIS AT DIFFERENT STOCKING RATES

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Abstract

Swards of 'Grasslands' Nui ryegrass, Roa tall fescue and Maru phalaris were grazed according to feed budgets to consume the estimated annual requirement of 15, 20 and 25 breeding ewes ha⁻¹. The effects of these 9 grazing systems on seasonal changes of, and interrelationships between standing herbage mass (V), achieved herbage consumption (C) and net herbage accumulation rate (G) are examined. The relationship of G to V varied between seasons, but for a full year G decreased by 3 kg DM ha⁻¹ day⁻¹ for each 1000 kg DM ha⁻¹ increase of V. Estimated consumption requirements were exceeded at 15 ewes ha⁻¹, were about adequate at 20 ewes ha⁻¹, but were deficient at 25 ewes ha⁻¹. At 25 ewes ha⁻¹ ryegrass provided 28% more consumed herbage than phalaris. Indications are that at stocking rates at which G is near maximum and differences between grass species important, intake, and hence per animal performance, may be restricted.

INTRODUCTION

The effect of botanical composition on animal production from grazed pasture has been reappraised recently. A symposium held by the British Grassland Society (1978) found that, for Britain, apart from legume content, there was inconclusive evidence for gains of animal production from varying grass species or cultivar of similar persistence in a particular climate and soil. The B.G.S. symposium highlighted the lack of information on how species and cultivar composition of pasture affects animal production from self-contained systems.

This finding is equally true for New Zealand. There are many reports on herbage dry matter production from species and cultivars, and on animal production from species and cultivar comparisons. However, these evaluations mostly fall short of comprehensive evaluations through the grazing animal because they were carried out for only part of the year, and/or used *ad libitum* or put and take adjustments. These practices by-pass the critical effect of variations of standing herbage mass on both plant and animal production in self-contained systems. This criticism is particularly relevant as grazing in New Zealand is year round.

Evaluations of alternative managements, species or cultivars through self-contained grazing systems measuring the output of animal product are costly and time consuming. These demands are increased if the need to account for interactions between stocking rate and management is accepted (Wheeler 1962) and the investigator is interested in obtaining measurements

to explain management responses. It is not surprising that evaluation of management options mostly fall short of the ideal, as is the experiment described. However, considerable progress could be made towards more meaningful evaluation of managements for farm systems by applying the constraint farmers have of meeting the day-to-day requirements of stock from a fixed area throughout the year. The reasoning behind this is well expressed by Willoughby (1975).

An ecological model describing predator (grazing animal) — prey (pasture) interactions (Noy-Meir 1975) provides a theoretical model for the experiment to be described. In the model both herbage consumption (C), and consequently production of the grazing animal, and net herbage accumulation rate of pasture (G) at a given time are determined by the level of standing herbage mass (V) present in a self-contained system. The relationship between C and V is asymptotic, C declining at an increasing rate below a critical level of V (Hodgson 1977). Cutting experiments have generally shown that G is increased by an increase in the interval between defoliation suggesting a marked relationship between G and V (Harris, 1978). This provides a theoretical basis for the advantage of rotational over continuous management, but grazing studies have not conclusively indicated this advantage. However, it has been shown that at very high stocking rates pasture production is reduced (Campbell 1969; McFeely *et al.*, 1977) but the reduction is less with rotational grazing (Campbell 1969).

4 cutting technique, simulating the removal of herbage by continuous and rotational management at different stocking rates, has shown the form of the relationship between G and V (Harris 1978). Further data of this form (Fig. 1) are from an experiment on ryegrass-white clover pasture simulating different classes of stock and mean parturition dates over a range of stocking rates. Estimates were obtained as follows:

$$G = (C + V_2 \cdot V_1)/n \text{ and}$$

$$V_m = (V_1 + V_2)/2 \text{ where}$$

C is herbage removed to meet stock requirements or conserved

V₁ is standing herbage mass at start of period

V₂ is standing herbage mass at end of period

n is number of days in period

Rotational management was applied in this experiment, so V_m for each system incorporates a range of regrowth stages. It is shown that the relationship varies considerably with time of year (Fig. 1). Acknowledging that animal effects cannot be adequately simulated by cutting, the technique was applied using breeding ewes as the 'defoliators'.

EXPERIMENTAL

The experiment compared the ability of swards based on 'Grasslands Nui' perennial ryegrass (*Lolium perenne* L.), 'Grasslands Roa' tall fescue (*Festuca arundinacea* Schreb.) or 'Grassland Maru' phalaris (*Phalaris aquatica* L.), each sown with clover, to provide annual consumed herbage dry matter (DM) yields of 14,000, 11,000 or 8,400 kg/ha. The yields are the

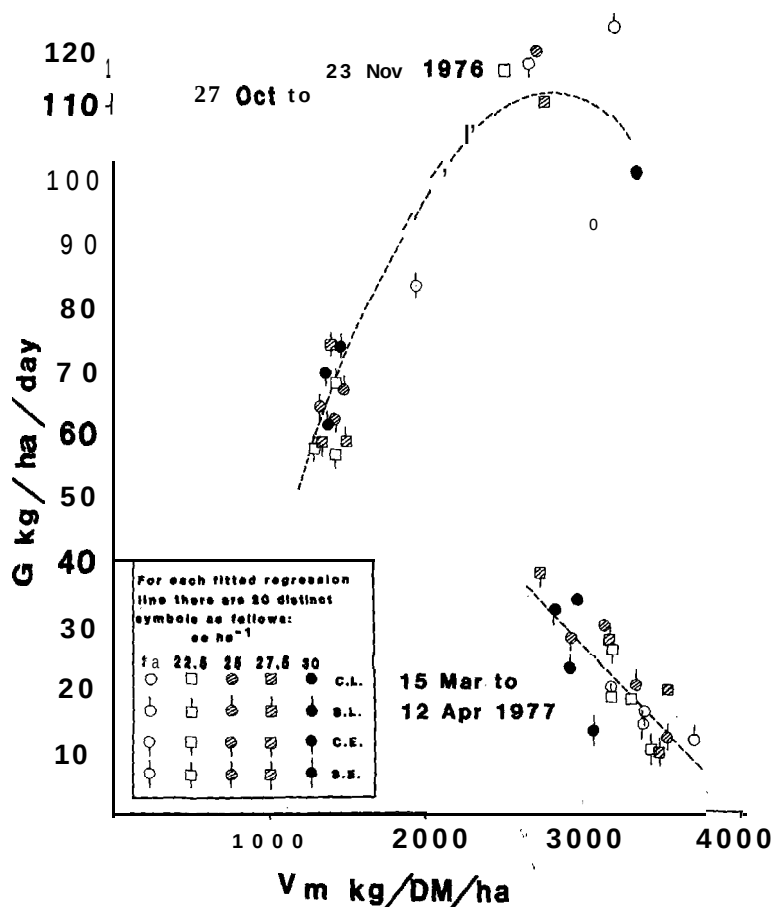


FIG. 1: Relationship at two periods between net herbage accumulation rate (G) and standing herbage mass (V) of 20 systems simulated by cutting to meet herbage requirements of ewes and cows with 2 parturition dates and 5 stocking rates.

SE Sheep early lambing.

SL Sheep late lambing

CE Cow early calving.

CL Cow late calving.

estimated requirements of 25, 20 and 15 ewe equivalents (ee) ha⁻¹yr⁻¹ assuming a 560 kg DM requirement per annum of a 55 kg breeding ewe. Using estimates provided by Jagusch and Coop (1971), a feed budget, which incorporated seasonal changes of the herbage DM requirements of breeding ewes and energy content of herbage, was drawn up for each stocking rate. Annual budgets started late December, with deficits or surpluses of consumed herbage being written off at this time.

The swards were sown in April 1976 and production evaluated for 3 years by cuts of herbage within enclosure cages after grazing by mobs of wethers. In April 1979 stocking rates were imposed by groups of 6, 8 and 10 ewes brought on to the experiment after tupping. Each of these groups of ewes and their lambs are self contained within 0.4 ha of measured paddocks and holding areas.

The 9 stocking rate X grass species systems each consist of 4 replicate paddocks of 20 x 10 m. The replicate paddocks of each system are grazed in rotation. Paddocks are sampled by cutting a transect 19.5 m long, the width of a shearing handpiece, to ground level before and after grazing. This provides estimates of herbage on offer, residual herbage after grazing, and by difference, herbage consumed. The quantity of herbage consumed is added to the feed budget and this determines the grazing date of the next paddock in the system.

The objective of meeting the feed requirement for each system sets the rate of rotation and level of utilization. In situations of herbage deficit the rate of rotation is set at a minimum of 3 weeks. During October to February paddocks with regrowth of more than 6 weeks are grazed by wethers and the herbage consumed recorded as surplus which can be balanced against deficits recorded at other times of the year. Ewes are grazed on the holding areas when the feed budget precludes grazing on the measured paddocks.

Every 3 months, V is measured by ground level transect cuts for all 36 measured paddocks. This allows construction of seasonal balances of C, average standing herbage mass (Vm), and G. Significance of system effects on C, G and Vm are tested by analysis of variance. Based on the Noy-Meir(1975) model, C and G are plotted in relation to target ewe herbage requirements, and by using the highest order significant polynomial fitting, regressed against Vm (Figs 1, 2). Seasonal changes for the year starting December 1979 are considered in this paper.

RESULTS

SUMMER (4 December 1979 to 2 March 1980)

Vm at 15ee was significantly higher than for the higher stocking rates, but similar for the three grasses (Fig. 2). Averaged over all systems G was 29.7 kg DM ha⁻¹day⁻¹ and was significantly higher at 25 and 20 ee than at 15 ee. The regression of G on Vm was significant, linear and negative, indicating a 4.8 kg DM ha⁻¹day⁻¹ reduction of G with each increase of 1000 kg DM ha⁻¹ Vm (Fig. 2).

With conservation grazings C was in excess of ewe requirement for all systems except phalaris at 25 ee. Consumption of phalaris was significantly less than of ryegrass. Averaged over all systems V declined from 2140 to 1550 kg DM ha⁻¹ during summer. This decline was particularly large for the low stocked ryegrass and fescue systems (Fig. 2). As G at the different stocking rates was similar to current ewe requirements, consumption in excess of requirement was possible by utilization of herbage accumulated in the spring period.

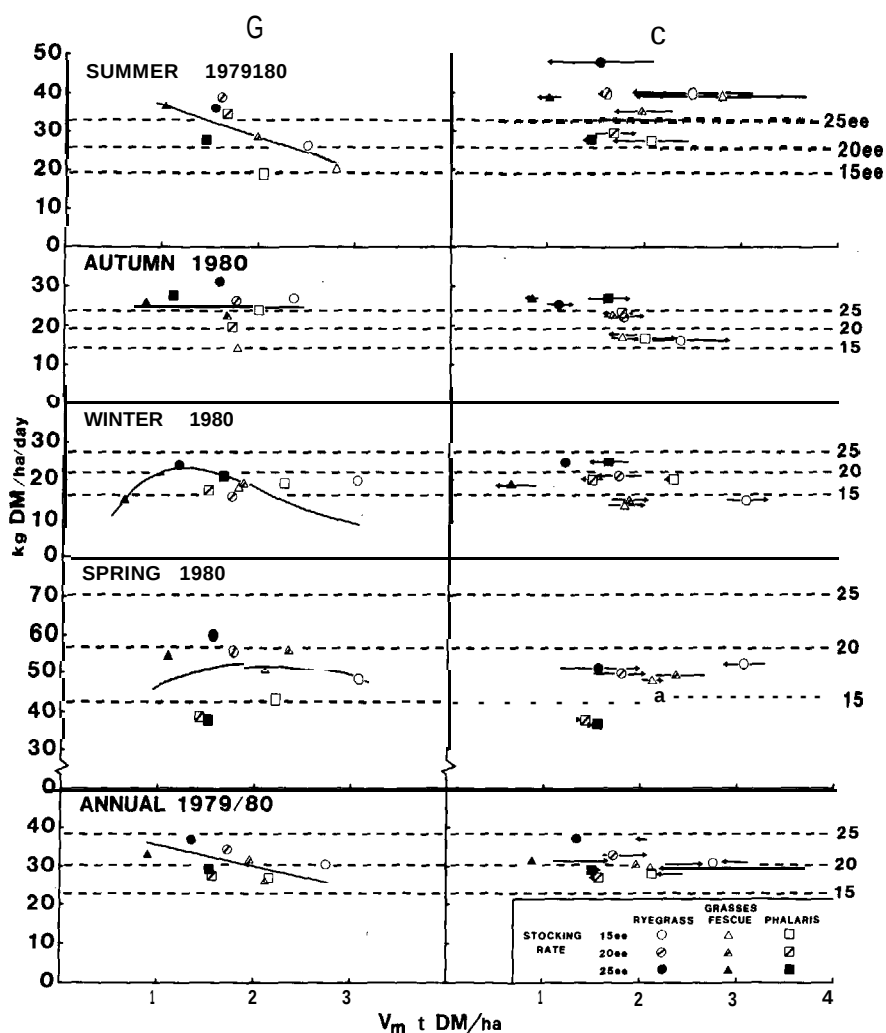


FIG. 2: Relationships between net herbage accumulation rate (G), consumption (C) and mean seasonal or annual herbage mass (V_m) for 3 grasses at 3 stocking rates. Means of G and C are plotted with reference to the seasonal and annual estimated daily requirements of ewes at the 3 stocking rates.

AUTUMN (3 March to 2 June, 1980)

V_m at 25 ee was significantly less than at 15 ee and was significantly lower for fescue than for phalaris (Fig. 2). G was not significantly correlated with V_m and averaged $24.2 \text{ kg DM ha}^{-1} \text{ day}^{-1}$ (Fig. 2). G for ryegrass and phalaris

was significantly higher than G for fescue. Fescue at 15 ee had particularly low G resulting in a significant stocking rate $\times$ species interaction (Fig. 2).

C to requirement level was obtained for all stocking rates and species (Fig. 2). During autumn V averaged over all systems increased from 1550 to 1770 kg DM ha⁻¹ and by the start of winter V ranged from 780 kg DM ha⁻¹ for fescue at 25 ee to 2870 kg DM ha⁻¹ for ryegrass at 15 ee.

WINTER (3 June to 31 August, 1980)

V_m decreased as stocking rate increased, and fescue had significantly lower V_m than ryegrass and phalaris. The interaction between stocking rate and species was significant and very low and high V_m of the 25 ee fescue and 15 ee ryegrass systems respectively are indicated. G averaged 18.7 kg DM ha⁻¹ day⁻¹ and was not significantly different between systems. A significant curvilinear regression indicates that G was reduced at low and high levels of V_m (Fig. 2).

Although C increased with stocking rate, C fell below the requirement level at the highest stocking rate, particularly for fescue (Fig. 2). As G exceeded C at the low stocking rates the low stocking rate systems increased V during winter whereas the higher stocking rates utilized autumn accumulated herbage to meet requirement. Averaged over all systems the change of V_m from the start to end of winter was small.

SPRING (1 September to 1 December, 1980)

Stocking rate means for V_m decreased from 2460 kg DM ha⁻¹ to 1390 at 25 ee, but these differences were not significant. The grass species had similar levels of V_m . G was similar for the 3 stocking rates, but G for ryegrass and fescue of 54 kg DM ha⁻¹ day⁻¹ was higher than G for phalaris of 40 kg DM ha⁻¹ day⁻¹. G showed a significant curvilinear relationship to V_m , but the amplitude of the response curve was small, varying from a minimum of 47 to a maximum of 52 kg DM ha⁻¹ day⁻¹ (Fig. 2).

Similar levels of C were obtained for the three stocking rates. By using wethers to consume surplus herbage C exceeded requirements at 15 ee. At 20 ee and particularly 25 ee C fell well below requirement. Phalaris had significantly lower C than ryegrass. Although C averaged over all systems fell below the requirement level, V , averaged for all systems, increased from 1740 to 2070 kg DM during spring (Fig. 2).

ANNUAL

Averaged over all systems V_m did not change significantly between seasons. Averaged over all seasons V_m declined significantly with increasing stocking rate, and V_m for ryegrass was significantly higher than that for fescue and phalaris. A significant stocking rate $\times$ species interaction arose largely from the very high and low levels of annual V_m of the 15 ee ryegrass and 25 ee fescue systems respectively (Fig. 2).

G changed significantly between seasons decreasing in the order spring > summer > autumn > winter. Averaged over all seasons G increased significantly as stocking rate increased. G for ryegrass was significantly higher than that for fescue and phalaris. A significant negative linear regression indicated a 3 kg DM ha⁻¹ day⁻¹ reduction of annual G with each 1000 kg DM ha⁻¹ increase of Vm (Fig. 2).

Seasonal C levels decreased in the the order spring > summer > autumn > winter. Annual C for 25ee, although below the requirement level for 25 ee, was significantly higher than C levels for 20 and 15 ee. Generally, annual C levels for the 9 systems were close to the annual requirement level of 20 ee indicating that this was about the sustainable stocking rate for the site in the year of the study (Fig. 2).

DISCUSSION

Pasture management to increase animal production has two broad objectives; to increase the quantity of digestible herbage available to the grazing animal, and to maximise the utilization of the available herbage without reducing animal performance below commercially required levels. The first objective involves maximising G, the second involves maximising C, but both C, and G in the variable ways shown in Figs 1 and 2, are dependent on V and both influence the level of V.

The clearer definition of the G, V relationship from the cutting experiment (Fig. 1) compared to the grazing experiment (Fig. 2) is obvious and has several possible explanations. One pasture association was used for the cutting experiment whereas the grazing experiment involved 3 different grass based associations each with distinctive levels of G irrespective of the level of V. Also, G, V relationships for cutting were estimated over a shorter period (Fig. 1) than for grazing (Fig. 2). The cutting experiments have shown that the relationship can change markedly in a few weeks so a season many include phases of both positive and negative responses to V which effectively cancel each other out depending on the range of V of the systems being compared. Further, differences between herbage removal by cutting and grazing probably act to modify the positive and negative aspects of the G, V relationship, grazing intake restriction probably limiting the reduction of V to levels where G is markedly reduced, while avoidance of dead matter by grazing animals at high levels of V leaves more material readily lost through decomposition.

Reduction of annual G as V (Fig. 2) increases appears to be contradictory to the results of most cutting and mob stock grazing experiments where harvested yield is increased by reduced defoliation frequency and intensity (Harris 1978). High levels of utilization are usually obtained in such experiments without having to account for the suitability of the herbage for animal production or whether it could be consumed at a given stocking rate. Once consumed, herbage is no longer available for loss through decomposition. Therefore, as cutting and mob stocking methods of determining herbage production optimize utilization, and minimise

decomposition which is the negative component of G , such determinations of herbage production are generally in excess of what can be achieved in self-contained grazing systems. Consequently, estimates of potential carrying capacities which have been made from cutting and mob grazing evaluations (e.g. Brougham 1977) are probably optimistic.

The levels of G obtained for the 15 and 20 ee stocking rates indicate these stocking rates fall into what Noy-Meir (1975) describes as an under-grazed steady state (Fig. 2). In this state, reduction of V by C increases G , whereas increase of V reduces G because of increased decomposition. It is therefore a buffered state, probably characteristic of most New Zealand pastoral systems. Within the range of stocking rates from 15 to 20 ee, productive output was increased simply by increasing stocking rate.

However, increasing the stocking rate above 20 ee, while continuing to increase G , resulted in a change to a state where the herbage grown was below budgeted, per animal requirement. In this state per unit area animal production could continue to increase but per animal production would decline with further increase of stocking rate. Further, the data suggests that per animal performance would be reduced below a commercially acceptable level before consumption reduced V to the low biomass steady state (Noy-Meir 1975) which is limiting to herbage growth per se with consequent reduction of unit area animal production. Transitory occurrence of this state was indicated for the 25 ee fescue system in winter (Fig. 2).

Observed annual consumption per ewe was well below that indicated by Jagusch and Coop (1971), this difference occurring mainly in spring when the average budgeted level was 2.82 kg DM per ewe (and lamb)-day⁻¹. The full effect of this intake deficit was masked by the technique used, wethers reducing the shortfall of herbage consumed at the low stocking rates, and grazing pressure by the ewes on the measured areas was intensified during spring using the holding area as a buffer. Intake averaged over all systems for spring was 1.70 kg DM ewe⁻¹ha⁻¹day⁻¹, close to intake measured by Clark (1979) who, using Romney ewes from the same flock as those used in this experiment, obtained an average daily intake of 1.77 on ryegrass white clover pasture. Differences between the grasses in intake were significant, increasing in the order phalaris (1.51) < fescue (1.74) ryegrass (1.86 kg DM ewe⁻¹day⁻¹, LSD 5% 0.15).

The measured intakes suggest that the seasonal change of ewe requirement from maintenance to lactation is less than indicated by Jagusch and Coop (1971). This limits the opportunity to consume current spring growth to prevent the accumulation of low quality standing herbage mass during spring which then stands into summer.

Averaged over all systems daily allowance during spring was 3.41 kg DM ewe⁻¹day⁻¹ of which 51% was utilized. Over the range of allowance from 2.04 to 5.27 kg DM ewe⁻¹day⁻¹ there was a significant ($p > .001$) linear relationship of ewe intake kg DM day⁻¹ = $0.81 + 0.26$ kg DM on offer ewe⁻¹day⁻¹. Disregarding the asymptotic nature of intake/allowance relationships, linear extrapolation indicated an allowance of 7.7 kg DM ewe⁻¹day⁻¹ to provide the

budgeted required intake of 2.82 kg DM ewe/day-1 at which level utilization would be 24%. Such an allowance level could not be sustained at the high stocking rate, and at low stocking rate the large residue of herbage left after grazing would lead to considerable herbage wastage and loss by decomposition. Although combined consumption of ewes and wethers exceeded the annual requirement of the ewes (Fig. 2), at 15 ee stocking rate the conserved herbage was not required to meet C deficits at any time of the year as current G was always above C at this stocking rate.

The contribution made by the grass species to the production of the 9 systems was clearly dominated to responses to stocking rate, and in this respect conforms to the classical stocking rate X management interaction illustrated by the comparison of management systems for dairy cattle made by McMeekan and Walshe (1963). All grass species were able to meet annual C requirements at 15 ee, phalaris was below the requirement level at 20 ee, and at 25 ee differences between G of the grasses had large effects on the quantity of herbage consumed (Fig. 2). At 25 ee, at which stocking rate herbage production is indicated to be near maximum for the site, annual consumption of ryegrass was 28% higher than that obtained from phalaris. Although these results are specific to the site and year, the wider indications are that as stocking rate on New Zealand pastures increases further, management of the grass composition of pasture will become much more important.

ACKNOWLEDGEMENTS

To Mr J. S. Mackay for technical assistance and Mr D. A. Clark for helpful discussion.

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