Impacts of Forage Cropping Decisions on Feed-Flows in Cool-Temperate Grazing Systems

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Abstract. Intensive cool-temperate grasslands often rely on adding forage crops to help supply feed when pasture growth is limited by cool temperatures and low sunlight. We tested the impacts of using single- or multi-graze crops to alter feed supply in either summer/autumn or winter on productivity in red deer farming systems in a cool-temperate environment. The choice of single-graze or multi-graze crops to provide forage in deer grazing systems had an impact on the feed flows and the amount of pasture available, with multi-graze crops supplying more feed during the dry summer months while single-graze crops supplying more feed during the cool winter months. The limited growth rates of young red deer, and the late calving of hinds meant that pasture covers could be low during the late winter and early spring without compromising animal production. Overall, the use of a multi-graze crop, especially when used early in autumn to promote weaner liveweight gain, increased overall productivity by 5% and increased feed conversion efficiency by 2.5% in the venison production system.

Introduction

Feed flows are the cumulative effects of pasture growth, senescence, and animal utilization on the amount of feed available at any time of the year. In seasonal cool-temperate grazing systems, transferring feed from one season to another using forage cropping is a common technique used to modify instantaneous feed supply depending on the target problem (Stevens 2009).

Winter feed deficit resulting from low seasonal pasture growth is often filled with single use winter crops such as swedes (*Brassica napus*) and fodder beet (*Beta vulgaris*). Variations in expected summer and autumn pasture growth is often filled with multi-graze crops such as rape (*Brassica napus* ssp *biennis*). More recently however, single use crops have been used to fill autumn deficits while multi-graze crops have been used to fill winter deficits. These changes have been in response to growing awareness of the impacts of stocking density on nutrient and sediment loss during *in-situ* winter grazing. However, these changes also alter the feed-flow on-farm with flow-on consequences to animal performance. The amount and quality of herbage on offer has a direct effect on the performance of the animals grazing that herbage (Woodward et al. 2001). Single-graze crops are suitable as a maintenance diet as they have a high metabolisable energy concentration but are often deficient in protein and other minerals (de Ruiter et al. 2009). Multi-graze crops offer a much more balanced diet, capable of meeting the feed requirements of finishing livestock (Stewart et al. 2022). We hypothesize that replacing single-graze with multi-graze forages will increase whole farm productivity and efficiency in a red deer farming operation.

Methods and Study Site

The strategies of using a multi-graze or a single-graze crop, either early (autumn/early winter) or late (late autumn/late winter) were simulated. Deer farm information from the 192 ha Invermay deer research farm (Lat. -45.85864, Long. 170.38754) provided base data livestock classes and numbers, and livestock performance (Table 1). Red deer calve during November and December, calves are pre-rut weaned in late February, mating occurs in April and May, and calves are targeted for slaughter during October and November, when carcass value peaks and before the next cohort is born.

Pasture growth (Figure 1A) was sourced from Round-Turner *et al.* (1976). Potential crop growth was calculated using a response rate of 11.1 kg DM/growing degree day above a base of zero degrees, and a water use efficiency of 20 kg DM/mm water used (de Ruiter *et al.* 2009). Temperature and rainfall data to inform the calculations were downloaded from the National Institute of Water and Atmosphere (NIWA)

virtual climate network (Tait *et al.* 2006) for the years 2016-2020, and the average crop yields were calculated.

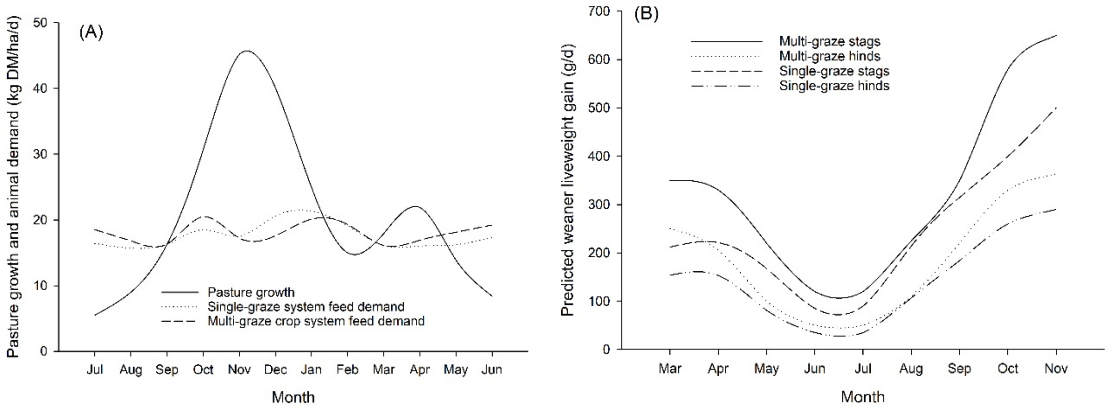

Figure 1. (A) Average pasture growth on the Invermay Deer research farm (Lat. -45.85864, Long. 170.38754), from Round-Turner *et al*. (1976), and feed demand of the red deer enterprises when using a multi-graze or single-graze crop. Note that June, July and August are winter; (B) Predicted liveweight gains of weaner stags and hinds fed either a multi-graze or single-graze crop during autumn, winter and early spring, or pasture.

Whole farm modelling predicted the outcomes of grazing single- or multi-grazed crops. Grazing began in either late summer (early) or late autumn (late) for the multi-graze crops, and late autumn and late winter for the single-graze crops. Multiple-graze crops generally yield approximately 60-70% of single-graze crops (de Ruiter *et al.* 2009), so the area in crop was increased from the current 10 ha for a single-graze crop to 15 ha for a multi-graze crop. The Farmax Red Meat (version 8.0.1.34 Science Edition, FARMAX Ltd, Hamilton NZ) software was used to develop the feed flow profiles of each scenario, and to generate farm performance data. The software uses relationships between feed on offer and potential to meet animal intake targets, and tests for feasibility. The use of single- and multi-grazing crops created differences in both the potential amount of feed available during a grazing event (the pasture cover) and the feed quality offered to animals, which affect the potential growth rates of young animals (Woodward *et al.* 2001). These effects (pasture cover and feed quality) were used to calculate weaner growth rates (Figure 1B) using the Q-Graze software (Woodward *et al.* 2001) and the growth rates adjusted in the model.

Table 1. Livestock types, numbers and performance on a 192 ha deer farm in a cool-temperate climate

Stock Type	Number	Liveweight (kg)	Carcass weight (kg)	Calving (%)
Mixed age hinds	500	130		92
Rising-two-year-old hinds	110	120		84
Finishing young stags	290	70*	73+	
Finishing young hinds	290	65*	60+	
Stags	32	210		

*Liveweight at weaning at 100 days of age.
†Carcass weight at approximately 12 months of age.

Results and Discussion

Total forage production

Crop yield (t DM/ha) was greatest for a single-graze crop utilized in the winter, and greater than the single-graze crop utilized in autumn (Table 2). The lack of ability to regrow after use meant that eating the crop early stopped any further accumulation of growth. Brassica crops will continue to grow at temperatures down to 0^{o}C (de Ruiter *et al.* 2009) so later use allows continued forage accumulation. The

multi-graze crop, while yielding less per hectare than the single-graze crop, expressed its full potential regardless of timing of first grazing, due to its ability to recover after initial grazing. Multiple-grazed crops increased the amount of crop grazed (expressed per farm area), increasing total feed eaten (Table 2).

Table 2. Farm areas, pasture and crop yields, feed eaten and performance outcomes when multi-graze or single-graze crops are used early or late to provide forage for a deer farming enterprise in a predominantly pasture grazed system in a cool-temperate climate.

		Multi-graze Crop		Single-graze Crop	
		Early	Late	Early	Late
Area	Farm Area (ha)	192	192	192	192
	Grazing Area (ha)	174	174	176	176
	Cropping Area (ha)	15	15	10	10
Feeding	Pasture yield (t DM/ha)	7.55	7.55	7.55	7.55
	Crop yield (t DM/ha)	7.65	7.65	7.5	10
	Pasture Eaten (t DM/Farm ha)	5.085	5.095	5.285	5.205
	Supplements Eaten (t DM/Farm ha)	0.26	0.26	0.26	0.26
	Crop eaten	0.60	0.60	0.312	0.42
	Total Eaten (t DM/Farm ha)	5.95	5.96	5.86	5.85
Performance	Production (kg Carcass/Total ha)	173.4	173.4	164.2	164.2
	Stocking Rate (SU/Total ha)	10.8	10.8	10.6	10.6
	Feed Conversion (kg DM/ kg Product)	34.3	34.3	35.5	35.5

Feed-flows resulting from multi-graze or single-graze crops, utilized either early or late

The late calving of red deer (November), combined with the requirement to finish weaners during winter created a consistent feed demand throughout the year (Figure 1). Pasture growth (Figure 1) was highly seasonal, with a summer dry period (January-March), and low growth in winter.

During late winter (July, August) the early-use multi-graze crop had the greatest net feed supply deficit, while the single-graze late-use crop had the least net feed supply deficit (Figure 2A). In spring, (August-November), all systems accumulated more feed that was required, though multi-graze crops began this process earlier, by mid-August. A net feed deficit developed in summer as pasture supply did not meet animal feed demand. This situation eased earlier with the early use of the multi-graze crop and persisted longest with the late multi-graze crop. A surplus of feed was generated briefly during autumn, being greatest with the late-use multi-graze crop, though shorter-lived than the early-use single-graze crop.

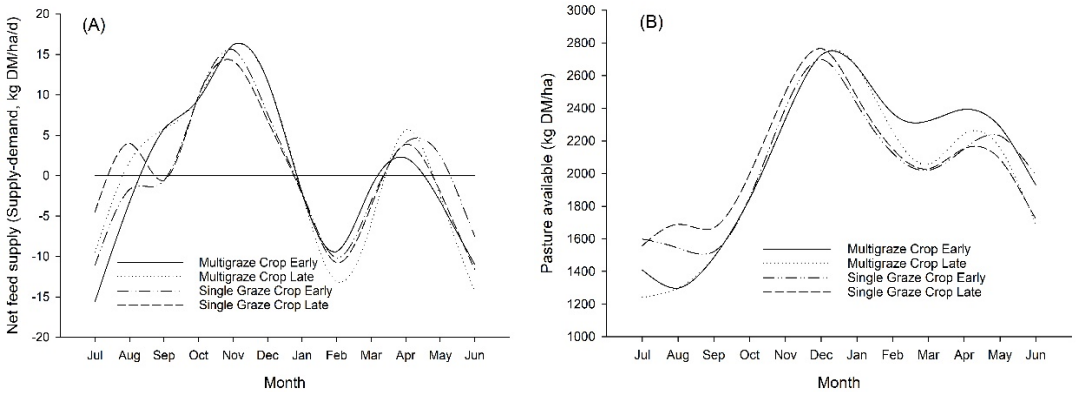

Figure 2. Net feed supply (A) and pasture available throughout the year (B) of a red deer farm using multi-graze or single-graze crops, grazing these crops either early or late. Note that June, July and August are winter.

Net feed supply changes impacted on the pasture available (Figure 2B). In winter, the single-graze crops maintained the greatest pasture cover. The multi-graze crops had much lower pasture cover which persisted until October. All pasture covers peaked in December. As net feed demand exceeded pasture growth, pasture covers began to decline from late December onwards, though the early-use multi-graze crop maintained higher pasture covers than the other systems. Some variation in pasture cover is seen in May and June, though falling cover is represented across all systems. The decline in pasture cover continues to be greater in the multi-graze crops than in the single-graze crop systems through winter.

Relative animal performance

Predicted weaner liveweight gains were higher in the autumn on the multi-graze crops (Figure 1). This was due both to the greater feed quality of the multi-graze crop, and to the higher effective pasture availability compared with pasture. The advantage of increased liveweight gain during the autumn carried over into greater potential to grow during the winter (Stevens *et al.* 2003) and the spring.

Implications for whole-farm performance

We hypothesized that implementing of a multi-graze crop strategy, rather than a single-graze crop strategy, would result in increased productivity. Using a multi-graze crop strategy increased carcass production by 5% and an increase in feed conversion efficiency of 2.5%, supporting the hypothesis. The impact of lower pasture cover during late winter was mitigated by the naturally lower growth rate of red deer in winter (Stevens *et al*. 2003), meaning high pasture covers were not required to meet intake requirements. These results provide an insight into red deer systems only, as they have a unique set of feed requirements, being influenced by the timing of growth in weaners and the calving dates and lactation requirements of the hinds.

Conclusions

The choice of single-graze or multi-graze crops to provide forage in deer grazing systems impacted on the feed flows and the amount of pasture available, especially during the dry summer months and cool winter months. The low winter growth rates of young red deer, and late calving of hinds allows low pasture covers during the late winter and early spring without compromising animal production. The use of multi-graze crops, especially when used early in autumn to promote weaner liveweight gain, increased overall productivity and increase feed conversion efficiency in the venison production system. The use of single- and multi-graze crop options in other livestock enterprises such as sheep or dairy may be quite different, due to the relative importance of available feed quantity and quality at different times of the year.

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