THE USE OF CROP GRAZING SYSTEMS FOR ANIMAL PRODUCTION

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ABSTRACT

This paper looks at the use of crop grazing systems as an alternative to all grass systems for cattle and sheep production. It suggests ways of using forage crops efficiently to increase animal production on a per animal and per unit area basis.

INTRODUCTION

The area of forage crops used as supplementary feeds in New Zealand has decreased from 312 000 ha in 1960/61 to 222 000 ha in 1972/73. This decrease may be due partly to an increased emphasis on all grass farming in order to save on cultivation costs.

Many of the advantages of forage crops however, have not been fully utilised in farming systems in the past. This paper shows how, by using forage crops, animal grazing systems may be greatly improved both in total animal production per hectare and in individual animal performance.

The major benefit of crops compared with pasture is their very high dry matter (DM) production, especially when 2 successive crops are grown each year. Trials at Invermay in the South Island have shown that crops can produce between 20 and 30 000 kg DM ha^{-1} $annum^{-1}$ whereas good pasture will only produce 12 - 14 000 kg DM ha^{-1} (Stephen and McDonald 1977). Mitchell (1963 and 1966) and Taylor *et al.*, (1976 and 1978) have shown that crops in the North Island can also produce about twice as much DM as pasture. In order to increase animal production per hectare, double cropping would therefore appear to have a large potential.

The poor animal liveweight gains (LWG) that are often obtained on pasture for varying periods during summer and autumn, commonly called "ill thrift" (Scott *et al.*, 1976), can also be partly overcome by grazing crops as an alternative to pasture during this time. McDonald *et al.* (1977a and 1977b) reported that with both hoggets and 16-18 month old beef steers, LWG's over the autumn on kale and especially on greenfeed maize were generally higher than LWG's on pasture when similar DM was available on all treatments. There would seem to be a need, therefore, for an economic crop-grazing system that makes use of the advantages outlined above, in particular the high DM production and the ability of crops to support better stock performance than pasture at certain times of the year.

There are two major methods of utilising crops, either conserving them or grazing them *in situ*. Most forage farming systems that have been suggested previously have been based on conserving the crops in order to harvest the maximum DM production (Mitchell 1963 and 1966, Taylor *et al.*, 1976). However, more recently crop grazing systems have been suggested (Stephen 1975, Stephen and McDonald 1977). The major advantage of grazing the crops compared with conservation is that even though some DM production is sacrificed, there are large cost savings, as no harvesting, storage or feeding-out machinery is necessary. In addition, with the return of dung and urine to the field there would be a lower requirement for fertilizer inputs compared with a cut-and-carry conservation system.

An economic report by an Interdivisional committee of the Ministry of Agriculture and Fisheries (Stephen *et al.*, 1974) using theoretical estimates of DM production, showed that for both beef and dairy at different levels of production, a crop grazing system would be more profitable than a pasture grazing system, however both would be less profitable than a crop storage system in terms of gross margin. Bell (1975) extended the above analysis and found that Returns on Capital for both dairy and beef feedlot systems were lower than for pasture or crop grazing systems. It would appear therefore that, although feedlot systems based on crop conservation would be capable of generating relatively large net profits, the requirement for large amounts of capital would probably make them uneconomic in terms of Return on Capital compared with grazing systems.

One further advantage of crop grazing systems is that farmers do not have to learn new grazing management skills if crops are strip grazed in a manner similar to that done on pasture. Crop areas that have been grazed may sometimes suffer from pugging especially during winter and slightly more cultivation may be required than on areas where crops have been conserved.

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SYSTEMS

Traditional

Forage crops have been mainly used in New Zealand as supplementary feeds at times of the year when pasture growth has been low. The major forage crops used have been brassicas for grazing during winter. However other crops are sometimes grown such as maize or kale in summer in drought susceptible areas, lamb fattening crops such as rape and autumn-sown greenfeeds which are commonly sown after cereal cash crops.

In most farming systems forage crops have been sown as part of a 2 to 4 year crop rotation prior to the regrassing of a small proportion of a predominantly grass system. Although they supplement pasture production, nevertheless they have generally not been used on a large scale to increase the total stock performance of a system.

Ruakura

Intensive double cropping aimed at increasing milk production per hectare from dairy cows is being studied by A. Campbell at Ruakura. In a part grazing part conservation system, maize is harvested for silage in March after which "Manawa" ryegrass is direct drilled into the maize stubble for grazing in winter/early spring. Maize is resown again in November either after conventional cultivation or by direct drilling after the Manawa has been sprayed with paraquat. A farmlet system involving half the area in pasture and half in this maize/Manawa rotation is making use of the high DM production of the crops and is running dairy cows at a higher stocking rate than would be possible on pasture alone. The profitability of this system however, has so far been no better than that from an all-grass system.

Lincoln

A lucerne/"Tama" ryegrass system for fattening beef weaners has been studied at Lincoln. In this all grazing system, irrigated lucerne was grazed for most of the year and in the autumn Tama was direct drilled into part of the lucerne area for grazing during winter/early spring. Total DM production of the 2 crops was higher than could be achieved on lucerne alone and the pattern of DM production was more evenly spread through the year than lucerne alone.

Invermay

There are 2 major crop grazing systems being studied at Invermay. Firstly there are 100% crop grazing systems on which animals graze high DM producing crops *in situ* throughout the year. These all-crop systems can have either no conservation or part conservation. Secondly there are 50% crop/50% pasture grazing systems where maximum benefit is made of both crops and pasture. In this latter system the pasture is grazed mainly in spring and summer while the crops are grazed in the autumn when "ill thrift" can be a problem on pasture, and in winter/early spring when pasture production is lowest. No conservation is required on 50% crop/50% pasture systems. Details of these 2 types of systems and their potential for beef and sheep production will be discussed more fully.

100% CROP GRAZING SYSTEM

An intensive double cropping rotation aimed at carrying beef weaners for 12 months of the year, is shown in Table 1. Half the area has summer sown kale for winter grazing rotating with September sown oats for summer grazing, while the other half has autumn sown oats for spring grazing rotating with spring sown kale and maize for autumn grazing. Part of the spring sown oats could be made into hay for use as an insurance crop for feeding when there are DM deficiencies. The assumed average DM yields for each crop during each grazing period have been estimated from plot trial data collected over several years at the Invermay Agricultural Research Centre. The theoretical total DM production of 21 000 kg ha^{-1} is much higher than pasture production of approximately 12 000 kg ha^{-1} in the south of the South Island (Stephen and McDonald 1977). Assuming an 85% degree of utilisation on both crops and pasture and a total DM requirement per steer of 2 604 kg, the stocking rate possible on the all-crop system is theoretically 6.8 weaners ha^{-1} compared with 3.9 weaners ha^{-1} on pasture. The DM requirement of 2 604 kg animal^{-1} assumes that weaners grow from 170 to 425 kg and is calculated from N.R.C. (1970) tables except that an additional 30% higher DM requirement has been assumed necessary during winter (Stephen *et al.*, 1977).

TABLE 1: An all-crop rotation for grazing beef weaners on 1 ha

Area	Half Year	Half Year
0.5 ha	KALE (Dec + Jan) Use: mid Apr - mid Sept. at 11 500 kg ha^{-1}	OATS (Sept) Use: end Nov - mid Jan at 9 000 kg ha^{-1}
0.5 ha	OATS (Mar + Apr) Use: mid Sept - end Nov at 10 000 kg ha^{-1}	KALE (Oct) + MAIZE Use: mid Jan - mid Apr at 11 500 kg ha^{-1}

Total DM production = 21 000 kg ha^{-1}
At 85% Utilisation available DM = 17 800 kg ha^{-1}

An economic appraisal of the theoretical all crop grazing system at 6.8 weaners ha^{-1} and an all pasture system at 3.9 weaners ha^{-1} was made by Stephen and McDonald (1977) and is summarised in Table 2. Costs were averaged over 5 years for the systems and animal growth was assumed to be the same in each system. The crop system had a gross income 72% higher than the all-grass system; however, the higher costs associated with the crops reduced its net income to 44% higher than that on all-grass. The major cost in the cropping system was for conventional cultivation carried out by a farmer with his own machinery. The cultivation cost included a charge made for labour per hour of cultivation, depreciation costs for a tractor and machinery as well as tractor variable costs. This cultivation cost could be decreased appreciably if crops were direct drilled. However research has not yet shown that direct drilled crops will constantly produce as much DM as conventionally cultivated crops. The results of this more recent economic appraisal confirmed the earlier report (Stephen *et al.*, 1974) that all-crop grazing systems should be more profitable than all-grass systems in terms of return on capital although this has not been studied and would depend on farm size and the proportion of a farm in a crop grazing system.

TABLE 2: Theoretical profitability of beef production on crop and grass systems

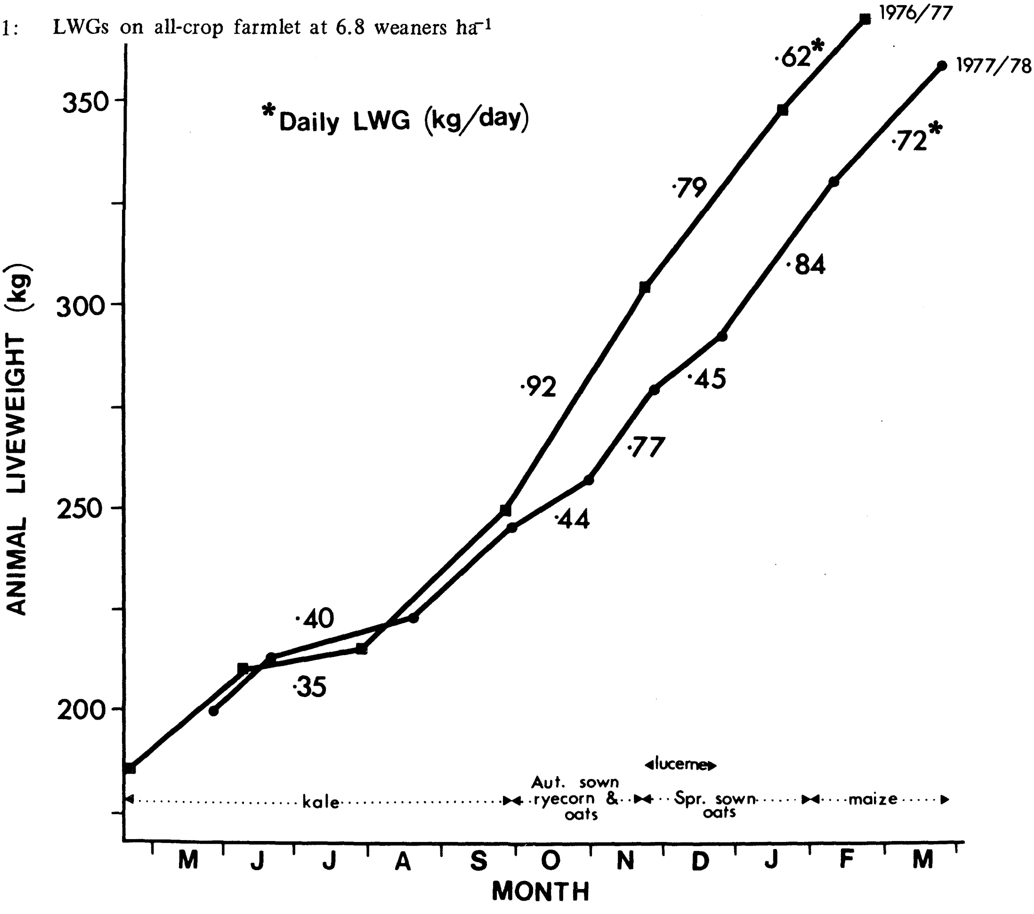
	All Crops @ 6.8 ha^{-1} $		All Grass @ 3.9 ha^{-1} $		50% Crop/ 50% Grass @ 5.0 ha^{-1} $	
Gross Income (64.28/animal)		437		251		321
Costs						
cultn.	72				36	
seed	35				18	
fert.	27		14		20	
hay	13		35		0	
		147		49		74
Net Income:		290 (+ 44%)		202		247 (+ 22%)

Beef weaners at 6.8 ha^{-1} have been grazed on a preliminary all crop grazing system during 1976/77 and 1977/78 (Stephen and McDonald 1978). In both years the weaners were on a crop rotation similar to that shown in Table 1 although in 1977/78, 10% of the area was in lucerne which was cut for hay for feeding as a high quality DM with kale in winter and at other times of the year when DM was deficient.

The major problem in these first 2 years was a much lower DM production than was expected. The total utilisable DM produced in each year was approximately 13 400 kg ha^{-1} compared with a predicted yield of about 18 000 kg ha^{-1}. The spring and summer in the first year were much wetter and colder than normal which reduced oat and especially maize yields. It also delayed the sowing of some of the second year kale by 6 weeks, which resulted in lower kale yields in winter than predicted. Winter pugging on kale in both years delayed the sowing of the spring-sown oats which were therefore lower yielding in summer when grazed. Maize in the second year was again low yielding, due to two factors not directly related to the system, bird and spray damage (chemical impurities in spraying equipment). Crop yields in some paddocks in the second year were also affected by soil nutritional deficiencies, mainly as a result of 2 cash crops being taken off the area prior to the farmlet systems. Individual crop yields were shown by Stephen and McDonald (1978).

Degree of utilisation on the crops was generally over 85% on kale, maize and on lower yielding oats, however on mature oats only about a 65% utilisation was achieved. Hay either made on the system or bought in was fed with most crops in order to

Figure 1: LWGs on all-crop farmlet at 6.8 weaners ha^{-1}



increase available DM, however at most times intake was restricted.

Consequently the LWG's achieved, as shown in Figure 1, were not high enough to achieve the target weight of 425 kg. Animals grew from 185 to 364 kg in 299 days (0.6 kg d^{-1}) in 1976/77 and from 199 to 361 kg in 301 days (0.54 kg d^{-1}) in 1977/78. The total liveweight gains of 1217 and 1102 kg ha^{-1} respectively were below the theoretical or target gain of 1730 kg ha^{-1}, however no higher LWG's ha^{-1} have been recorded in the south of the South Island although in one year out of four a similar LWG ha^{-1} was reported on all-grass by Monteath (1972).

Clearly two year's experience has failed to achieve predicted potential production. It is possible the experimental data on which the potential was based, was obtained in abnormally good growing conditions. Alternatively poorer than average conditions may have been encountered in the two years over which the system has been tested. Answers to this problem will not be known for several more years.

The past two years experience has highlighted certain deficiencies in the system and the following research is necessary to enable it to approach the predicted potential:

1. Direct drilling to enable earlier crop sowing.
2. Back fencing/pad feeding to reduce pugging on kale.
3. Use of cold tolerant varieties of maize to improve crop yield and reliability.
4. Improvement in cereal utilisation in late spring and late summer possibly through the use of urea.
5. The use of more nutritious legumes grazed at a higher degree of utilisation as an alternative to mature cereals of lower feeding value.
6. Evaluation of inter-relationships between crop yield, lower feeding value, % utilisation and nutritive value.

50% CROP/50% GRASS SYSTEM

A crop/grass system involving half the area in crops similar to those used in the 100% crop rotation and half the area in pasture, is shown in Table 3. The grass is used when it is highest producing and has a superior quality between October and December and also in January/February and in late autumn/early winter. The use of grass in the spring and late summer overcomes the need to graze mature oats at these times when it is difficult to obtain high degrees of utilisations. Spelling the pasture during most of the winter/early spring prevents winter pugging and should allow a large bulk of pasture DM to be available in mid October for the animals to make maximum spring LWG's. The crops are used mainly during winter/early spring when pasture production is lowest, but also for a short period in summer and again during autumn for finishing the beef. This system has advantages in that conservation is not required and the grass and crop areas could be rotated approximately every 4 to 5 years or a part of the area each year.

The estimated total DM production of this system is 15 500 kg ha^{-1} which at 85% utilisation is enough to carry approximately 5.0 weaners ha^{-1} assuming a DM requirement of 2604 kg $animal^{-1}$. This system has high quality DM available throughout the year and is likely to produce a better per animal performance at a stocking rate of 5.0 ha^{-1}, than can be produced on either an all-crop system at 6.8 ha^{-1} or an all-grass system at 3.9 ha^{-1}. In Table 2 however, where the profitability of this system is compared with that from the all-crop and all-grass systems a similar per animal performance to that on the other systems has been assumed. The profitability in terms of net income (Table 2) shows that this system has 22% higher net income than the all-grass system, but this would be higher if individual animal performance was superior on the crop/grass system as has been suggested.

TABLE 3: A 50% crop/50% grass rotation for grazing beef weaners on 1 ha

Area	Half Year	Half Year
0.25 ha	KALE (Dec + Jan) Use: Jul - mid Sept at 10 500 kg ha^{-1}	OATS (Sept) Use: mid Dec - mid Jan at 9 000 kg ha^{-1}
0.25 ha	OATS (Mar + Apr) Use: mid Sept - mid Oct at 6 000 kg ha^{-1}	KALE (Oct) + MAIZE Use: mid Feb - mid Apr at 12 500 kg ha^{-1}
0.5 ha	GRASS at 12 000 kg ha^{-1} Use: mid Apr - Jun mid Oct - mid Dec mid Jan - mid Feb	

Total DM production = 15 500 kg ha^{-1}
At 85% Utilisation, available DM = 13 200 kg ha^{-1}

At Invermay, 5 farmlets (each 4.0 ha) were set up in autumn 1978 to investigate the economics of beef production on crop and pasture-grazing systems. Two all-crop grazing systems at 6.25 and 5.0 animals ha^{-1}, two all-grass systems at 3.75 and 5.0 animals ha^{-1} and a 50% crop/50% grass system at 5.0 animals ha^{-1} are in operation.

SHEEP PRODUCTION

The systems presented in Tables 1 and 3 are especially designed for beef weaner production. Some work has also been carried out at Invermay on the use of crop grazing systems for sheep production. A crop grazing system at 32.5 ewes ha^{-1} and an all grass system at 20 ewes ha^{-1} were run for 2 years in 1976/77 and 1977/78. The crop system consisted of 75% crop/25% pasture in the first year and 90% crop/10% lucerne in the second year. The total lamb and wool production were higher on the crop than the grass system, but production per ewe was much poorer on the crops, as several problems were found when grazing ewes and lambs on a predominantly crop system. During the spring, LWG's of both ewes and lambs were very poor on oats in the first year and only marginally better on Tama in the second year. The lamb growth rates were affected by ewes having a low milk production especially on the oats, probably due to Ca and Vitamin D deficiencies in their diet. Degrees of utilisation on reasonably mature cereals were only 50-60% although over 80% was achieved on kale, maize and immature greenfeeds.

There are practical difficulties which require a greater labour involvement when strip grazing crops with sheep compared with cattle. With cattle only one electric wire is necessary and it can usually be shifted across the top of the crop, whereas with sheep 3 or 4 wires are needed and breaks have to be cut through the crop.

A 50% crop/50% grass system for sheep production will probably have more potential compared with a 100% crop-grazing system. Table 4 shows a possible 50% crop/50% grass system which as with the cattle system, makes good use of both pasture and crops. This system should give good lamb growth rates during the spring with pasture and Tama both being available, but good LWG's should also continue after weaning in early December when rape and pasture are available for the lambs. The ewes after weaning would be maintained on oats during December and then clean up the pasture after the lambs. Another advantage of this system is that reasonably reliable yielding good quality crop DM is available for ewes in autumn prior and during mating. This should ensure good liveweights and consequently a high lambing percentage. Conservation is not necessary in this system as kale is available during winter for maintaining ewe liveweights.

TABLE 4: A 50% crop/50% grass rotation for sheep grazing on 1 ha

Area	Half Year	Half Year
0.25 ha	KALE + MAIZE (Nov) Use: Feb - April @ 12 000 kg ha^{-1}	TAMA (Mar - May) Use: Oct @ 8 500 kg ha^{-1}
0.25 ha	KALE (Dec + Jan) Use: mid Jun - mid Sept @ 10 500 kg ha^{-1}	OATS (Sept) Use: Dec @ 8 000 kg ha^{-1}
		RAPE (Sept) Use: Dec - early Jan (lambs) @ 5 000 kg ha^{-1}
0.5 ha	GRASS at 12 500 kg ha^{-1} Graze ewes: Graze lambs:	 Jan May - mid June mid Sept - early Oct Nov early Jan - Feb

Total DM Production = 15 800 kg ha^{-1}
At 85% Utilisation, available DM = 13 400 kg ha^{-1}

The total theoretical DM production of 15 800 kg ha^{-1} in this sheep system is similar to that on the cattle crop/grass system. Assuming a DM requirements of 500 kg ewe^{-1} and an 85% degree of utilisation of the crops, this system should carry 26.8 ewes ha^{-1}. This stocking rate is 26% higher than the 21.2 ewes ha^{-1} theoretically possible on pasture yielding 12 500 kg ha^{-1} of which 85% is utilised. Apart from the increase in stocking rate over an all-grass system, the main advantage of a 50% crop/50 grass system is probably its potential to increase individual animal performance especially lambing percentage.

SUMMARY

Crops have the potential to increase animal production per hectare because of their high DM production. From Agronomic data collected in the south of the South Island over the last few years, it appears that kale and autumn and spring sown oats are more reliable DM producers than maize, mainly because the maize varieties available are not adopted to the cooler conditions in the south of the South Island.

High degrees of utilisation and reasonable LWG's have generally been achieved on kale, maize and on greenfeeds up to a certain stage of growth; however on mature cereals in late spring and late summer high degrees of utilisation are difficult to achieve. This may be overcome however, by substituting other crops (e.g. legumes) or possibly by spraying urea onto the crop prior to grazing. LWG's on kale are limited by an anaemia problem (Barry 1978), although reasonable winter gains of over 0.5 kg day^{-1} are still possible.

Fertiliser and weedicide requirements in crop grazing systems are not known, neither are the effects that continuous cropping and cultivations may have on soil structure, although this is expected to be small especially if crops can be direct drilled successfully.

One hundred per cent crop grazing systems may be more suitable for beef production than for sheep production, although 50% crop/50% grass systems appear to have considerable potential both for sheep and cattle. The major advantages of mixed crop/grass systems are that they should give better individual animal performance in addition to higher stocking rates compared with all-grass; they need no conservation and areas can be interchanged to maintain a high fertility.

The potential of crop grazing systems is considerable, but only experience will show whether animal performances achieved on such systems make them more profitable than all grass systems. Two year's testing of crop grazing systems has failed to achieve the predicted potential, but it is not possible at this stage to determine whether this is due to abnormal seasons being encountered or to an over prediction of potential.

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