AN ECONOMIC APPRAISAL OF DOUBLE CEREAL CROPPING

D.J.G. Davies
Crop Research Division, DSIR, Lincoln
B.A. Neilson
Kempthorne Prosser Ltd., Christchurch

ABSTRACT

Preliminary experiments at Otara and Lincoln in 1974/75 examined the yields and nutritive value obtainable from a double forage cropping system. Several cereals and one grass cultivar were grown for winter forage and maize for summer forage. Fertiliser responses were investigated. The results were subjected to economic analysis and compared with those of earlier authors particularly Mitchell (1974) and Philpott **et al.** (1972). Variations and avenues for future research are suggested.

INTRODUCTION

Cereals for consumption as greenfeed are widely grown in New Zealand. If not grazed too heavily they are left for a grain crop.

Recently, agronomic and physiological research groups have begun investigating the forage potential of the whole plant when harvested at the soft dough stage (S.D.S.) of grain formation. During, Mitchell and Lancaster (1973) suggested deficiencies in our knowledge relating to the role of High Yield Forage Crops (H.Y.F.C.) though the concept, as an alternative to pasture, has been promoted for some time (Mitchell 1966, 1969, 1974).

Double cropping may use many cultivars and crop sequences, but implies growing two crops in 12 months. Crop Research Division, Lincoln, has been investigating the yield and suitability of a range of H.Y.F.C. cultivars for the coolpart of the season, April-October. This has been followed by assessment of forage maize [**Zea mays L.**] when sown on the same site in November for forage harvesting at the S.D.S. by April, or earlier in northern regions.

Philpott, Greig and Wright (1972) demonstrated, on the basis of a hypothetical model, that storage of silage and haylage in high-cost silos would be uneconomic in comparison with grazing. This paper re-examines some aspects of the economics of pastoral production compared with forage systems. The costs are presented in terms of cents/kg of utilised dry matter. Recent production data from double cropping at one South Island and one North Island site with H.Y.F.C. cultivars are compared with pasture production estimates of grassland scientists. The influence of forage feed quality is also examined.

EXPERIMENTAL

Four trials, two winter and two summer, were conducted in the 1974/75 season at one North Island site, Otara, and one South Island site, Lincoln. The winter trials compared oats [**Avena sativa**], wheat [**Triticum aestivum**] and barley [**Hordeum vulgare**] with Tama tetraploid ryegrass [**Lolium multiflorum**].

Both the winter trials included nitrogen as a treatment and that at Lincoln measured phosphate and nitrogen responses and interactions. The layout was a standard randomised block design, three replications, with plots split for fertiliser comparisons. Samples from the Lincoln double forage site were analysed by Applied Biochemistry Division for protein, soluble sugars, cellulose, lignin and ash in order to calculate the A.D.F. (acid detergent factor) and digestibility values. For seeding rate and cultivars used see Table 1.

1. OTARA CEREAL

Drilled in 177 mm x 10 m drills on 1 May 1974 on Otara clay loam following a heavily-manured potato crop. Superphosphate was applied at 200 kg/ha as a basal dressing for all treatments. Nitrogen was applied to subplots at sowing, as sulphur-coated urea (32% N) at 35 kg/ha of elemental N. Total dry matter yield was determined from four 0.25 m^2 quadrats per treatment, taken on 17.10.74. All cereal cultivars were silorated and the ground rotary hoed in preparation for sowing the forage maize cultivar trial. 30 kg/ha of urea had been broadcast during cultivation to accelerate decomposition of the stubble and roots of the previous cereal crop.

2. OTARA MAIZE

Planted by hand 4 November 1974 at 150 mm spacing in two row plots with rows 610 mm apart and 6.1 m in length. No fertiliser was used at sowing. Total dry matter yields were determined from whole plot harvest on 26.2.75. The highest yield was obtained from an Australian cultivar, maize hybrid GH-128, and only results from this are reported here (see Table 2). The plant population established was 110,000/ha.

3. LINCOLN CEREAL

Drilled in 150 mm x 10 m drills on 6 May 1974 on a Templeton silt loam after a bean crop. Phosphate as superphosphate (9% P) was drilled with seed on appropriate subplot at 28.0 kg/ha. Nitrogen as urea (46% N) was broadcast by hand on 17.7.74 on subplots at 56.0 kg/ha. All plots were treated with Thimet to control aphids. Total dry matter yields were determined from 5 m x 1.4 m mown plots harvested on 31.10.74. The site was cleared with a forage harvester, and rotary hoed in preparation for sowing of the maize forage fertiliser trial.

4. LINCOLN MAIZE

Drilled with Stanhay "Jumbo" precision seeder on 8 November 1974 in 12 row plots 30 m x 610 mm and hand thinned to obtain a population of 110,000/ha. The cultivar used was maize hybrid W 346, sown at the rate of 130 kg/ha. Fertiliser treatments NO, N50, N150 kg/ha x KO, K125, K250 kg/ha were broadcast by hand on 29.11.74. The plot size was 9 m^2 and there were three replications. One metre ^{2} plots for each treatment were harvested by hand on 20.3.75. The crop was irrigated three times to a total of 150 mm water per hectare. The highest yielding treatment, selected here for economic appraisal, had received 50 kg/ha of nitrogen and was inter-row cultivated to control weeds (see Table 2).

RESULTS

A. Forage Yields

At Otara all cultivars except Tama ryegrass yielded in excess of the hypothetical target of 10,000 kg/ha of DM for cool season growth. At Lincoln no cultivars surpassed this yield. This was not unexpected and may have been brought about by the later sowing date and the excessively wet conditions experienced throughout the greater part of the growing period.

TABLE 1 Dry matter yield & seed rate (kg/ha) for cereals and grass at two sites and fertiliser interaction at one site

Cultivar	Seed Rate	Otara Mean	Lincoln O	N	P	NP	Mean
Mapua oats	135	14790 A	4424	8129	6709	8458	6930 bB
Karamu wheat	112	13556 A	6326	8513	7794	8687	7830 aA
Kakapo barley	112	10798 B	4273	6951	6664	6671	6140 cB
Tama Ryegrass	34	6330C	4377	8679	6419	8051	6881 bB
		Mean	4850 C	8068 A	6897 B	7967 A	

At Otara there was no significant response to nitrogen, and the oats and wheat significantly outyielded the barley and ryegrass (P .01). At Lincoln phosphate gave no increase in the presence of N and nitrogen gave some increase (P .01) in presence of P. However both N and P gave large increases when considered separately. At both Otara and Lincoln maize forage yields were in excess of the hypothetical target of 30,000 kg/ha of DM for warm season growth. The two cultivars given in Table 2 represent the highest yield in the maize fertiliser trial at Lincoln and the highest yield in the forage maize cultivar trial at Otara. In another trial at Lincoln the two cultivars gave similar yields. These results are the basis of the economic analysis for double-crop H.Y.F.C. systems.

B. Economic Analysis

Average specific costs were calculated as shown in Appendix 1 and are based on the experimental data given above for maize and Karamu wheat when double cropped for forage harvested as silage.

TABLE 2 Maize Cultivar Dry Matter Yield (kg/ha)

Site	Cultivar	DM %	Yield	Days to Harvest
Lincoln	W 346	35.0	30520	132
Otara	GH 128	22.9	42600	115

Following harvest of the maize crop in early April, the paddock is immediately prepared (three grubbings) for wheat. The cultivar Karamu is drilled at the beginning of May at 112 kg/ha. The following fertiliser is applied per hectare (Philpott **et al.** 1972).

	Lincoln	**Otara**
At drilling	96 kg N	168 kg N
At drilling	19.5 kg P	34 kgP
At drilling	173 kg K	300 kg K
Broadcast in early August	96 kg N	168 kg N

Crop weeds are sprayed in early spring and harvesting is completed in late September/October when grain formation at Otara is at the S.D.S. The ground is then cultivated (three grubbings) for maize and in November 50 kg/ha of maize seed is sown, with the following fertiliser programme.

	Lincoln	**Otara**
At drilling	91 kg N	122 kg N
At Drilling	34 kg P	46 kg P
At drilling	189 kg K	272 kg K
Broadcast in January	91 kg N	122 kg N

The crop is sprayed for annual weeds and army worm.

Both crops are harvested with fine chop forage harvesting equipment at approximately 25-30% DM content. The wheat crop is mown first and harvested with a pickup on the forage harvester. Crops are ensiled in bunkers and fed out as described by Mitchell (1974).

The Lincoln crop is irrigated (150 mm/ha) at an energy consumption of 468 kW hours/hectare (Heiler pers. comm.). There is no subdivisional fencing.

Losses due to wastage in harvest and storage are taken to be 13% for both crops (Philpott **et al.** 1972).

This system of production results in a cost per kilogram of utilised dry matter of 2.82 cents at the Lincoln trial site and 2.65 cents at Otara.

The following programme based on input costs set out in Appendix 2 is used to calculate the cost of grazed pasture.

Levels of pasture production used are as follows:

Otara 14500 kg/ha Hutton 1973, Piggot (pers. comm).

Lincoln 12000 kg/ha Brown (pers. com.), Stephen (pers. comm.).

No cropping or pasture renewal programme is envisaged. Utilisation is by beef cattle under intensive breakfencing with back fence. The length of grazing rotation is designed to suit seasonal fluctuations in rate of pasture growth. Sufficient hay is made from this grass to equal 10% of annual production at Lincoln and 5% at Otara.

Assuming good-average management and stocking rates which attempt to equate feed supply and demand through the season, 15% wastage from grazing has been allowed. This wastage is slightly higher than that suggested by Hutton 1973, who stated that at stocking rates of 4 milking cows per hectare or more, and with proper management, the animals will consume more than 90% of the grass grown during the year.

Interest or depreciation is only charged against items not common to both systems.

The results show significantly lower costs for grazed pasture production than for double forage (see Table 4).

An assessment of the nutritive value of the cereal,

TABLE 3: Nutritive analysis of Cereal, Ryegrass and Maize Forage: Lincoln Double Crop Trial 1974/75.

Cultivar	% Protein	% Hemi-cellulose	% Soluble sugars	ADF	% diges-tibility	MJME/ kg DM
Kakapo barley	5	14.7	10.0	29.9	61	9.0
Karamu wheat	6	14.1	7.1	23.0	67	9.9
Mapua oats	5	10.6	26.4	21.3	69	10.3
Tama ryegrass	4	9.0	24.5	21.7	69	10.3
Maize W346 NO	7	19.4	8.6	14.0	76	11.2
Maize W346 N50	7	14.2	9.6	11.9	77	11.3
Maize W 346 N100	10	17.4	12.3	10.0	79	11.7

ryegrass and maize cultivars grown at Lincoln site was obtained from analysis of composite ground samples by Applied Biochemistry Division, DSIR (Table 3).

It can be seen that protein contents of all crops are relatively low in relation to the requirements of growing and lactating ruminant animals, and when compared with conventional ryegrass-white clover pasture or lucerne. Protein supplementation would be necessary with these feeds. The ADF values however are indicative of high quality succulent feeds. Digestibilities predicted from the data of Van Soest (1963) are given in Table 3. The values are intermediate between those typical of grain-based rations and those of roughages. The calculated ME values for maize in this experiment are equal to average values for leafy rotationally grazed pasture whilst those for the cereals and Tama ryegrass are equivalent to more mature pasture (Jagusch pers. comm).

DISCUSSION

All the cereal and ryegrass cultivars used were commercially available. They were selected for their cool season activity and different maturity from vegetative growth phase. Only Karamu wheat met all criteria of early maturity to S.D.S. and freedom from disease by target harvest date (mid October). Mapua oats contributed the greatest bulk of feed in the north but at harvest were noticeably affected with leaf rust. There was less rust at Lincoln. Both Mapua oats and Tama ryegrass remained vegetative and would have been less affected by rust had they been harvested at least two weeks earlier at Otara. Kakapo barley was intermediate in performance, but anthesis occurred too late for grains to fill to the S.D.S. stage. This cultivar also showed some susceptibility to mildew and B.Y.D. virus. No disease of any consequence was observed amongst the maize cultivars. Many more cereal forage cultivars of local and imported origin are currently being screened and the best of these will be tested against the best of the original standards already described. Several promising lines of forage maize with acceptable leaf-stem/grain ratios, maturity for forage, and significantly higher total yields than grain maize selections are gradually becoming available.

Production of Double Crop System compared to Pasture

Figure 1 compares the hypothetical production of Philpott **et al.** (1972) and Mitchell (1974) with actual production data from one North Island and one South Island site, Davies (1975).

Cost of Forage from Double Crop System

The calculated direct costs of forage obtained by the double crop system are higher by 74% for Lincoln and 64% for Otara than that obtained by Mitchell (1974) from what is essentially the same system. Some difference is attributable to increases in costs during the past 12 months. However, there is also a wide difference in the cost of fertiliser inputs. The rates used in this analysis are based on those of Philpott **et al.**, and adjusted for yield, with a small allowance for species differences. Philpott **et al.** used the estimated nitrogen, phosphate, and potassium removal in the harvested material, from which the nutrients returned in effluent were deducted. As a result, fertiliser accounts for 27-30% of the calculated total direct costs ($258 to $401/ha or 0.7 cents/kg DM) of the double crop system (see Appendix 1).

However in Mitchell's paper no mention is made of provision for the return of effluent, and yet the total fertiliser applications amount to only $60/ha or 0.16 cents/kg DM far less than the 0.7 cents /kg DM used in this economic analysis to produce similar yields.

The fertiliser trials conducted at the Lincoln site with these crops on a soil which had had a moderately exhaustive cropping history indicated that the following fertiliser would provide near-maximum yields.

	Maize	Wheat
Nitrogen	75 kg/ha	56 kg/ha
Phosphate	35 kg/ha	28 kg/ha
Potassium	Nil	Nil

This fertiliser policy would cost $84/ha or 0.21 cents/kg DM produced and would have the effect of reducing the total direct costs of the double forage system (Lincoln site) by 17% from 2.82 to 2.35 cents /kg DM (see Table 4).

Cost of grazed pasture

Philpott **et al.** used the animal requirement method to estimate dry matter production from grazed pasture. Their data on the production of utilised dry matter from a central Auckland dairy farm and South Island intensive fattening farm are likely to provide a satisfactory comparison with the Otara and Lincoln trial sites. The costs used by Philpott **et al.** are taken as a base, interest is excluded and the total increased by 35% (Lincoln) and 41% (Otara) for the provisional increase in

TABLE 4: Average Specific Cost, cents/kilogram dry matter

System	Lincoln	Otara
Double forage	2.82	2.65
Double forage (Crop Rotation)	2.33	-
Grazed pasture	1.04	0.73
Grazed pasture (Mitchell)	-	2.20
Grazed pasture (Philpott)	0.81	1.73

prices paid by sheep and dairy farmers respectively from 1971/72 to 1974/75. On this basis it will be seen from Table 4 that grazed pasture production costs are 0.81 cents/kg DM (sheep) and 1.73 cents/kg DM (dairy).

The method used by Philpott **et al.** has distinct advantages. The problems of quantifying wastage at grazing, and the influence of such factors as grazing interval and trampling on the theoretical level of production obtained in mowing trials, are overcome, They also checked their results with two alternative "land output" approaches and found a satisfactory correlation.

However, according to their data, the costs of producing grazed pasture on a dairy farm are double that of a South Island sheep farm.

Also the method used by Philpott **et al.** results in a total utilised dry matter production of only 7020 kg/ha/year for a South Auckland dairy farm.

CONCLUSION

This paper indicates the yields obtained from the double cropping forage system, and also the direct costs required to produce dry matter by this method and from pasture.

Increased animal production allied to increased crop production should however be seen in the light of the total production system, and the scale of operations. It os planned in conjuction with Lincoln College to construct a model for computer analysis in order to examine the effects of total farm costs.

Analysis of the direct costs of the double forage silage system shows that approximately 55% of the total specific costs are directly related to harvest, storage and feed delivery. With these costs excluded by harvesting **in situ** on a continuous forage feed system, reductions in costs would accrue.

Research is also required on an experimental farm scale to obtain an objective assessment of the following factors:

1. Comparative feed quality studies with various classes of livestock.
2. Feed losses associated with animals (Mobile and standing), mechanical harvesting, storage and delivery.
3. Fertiliser maintenance rates for continuous cropping and rotational systems.
4. Comparison of forage utilisation systems and crop combinations.

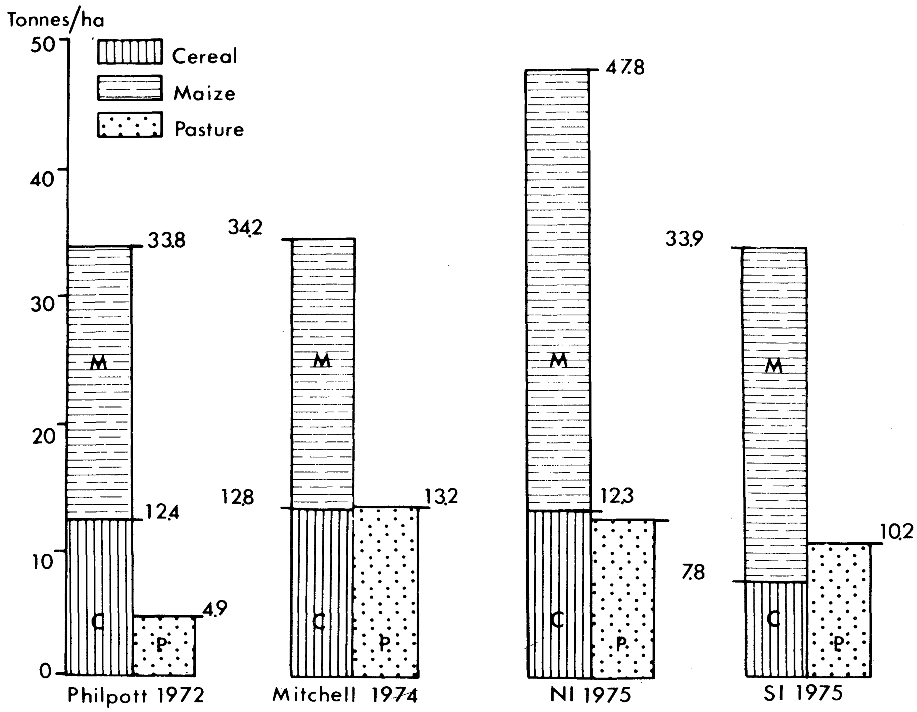

Fig 1: Utilisable dry-matter systems

5. Utilisation of solid effluent for recycling via animals, and liquid residue for maintaing soil fertility.

Our results support the hypothesis that substantially higher yields can be obtained from forage crops other than grass, the costs, and returns associated with utilising this increased dry matter require further study.

ACKNOWLEDGEMENTS

E. Stevenson for statistical analysis, S.E. Brennan for nutritive analysis, R. Lash. R. Hanson for assistamce, Dr H.C. Smith, Dr J.W. Sturrock, G.M. Wright, Dr C. Jagusch and Prof. J.B. Dent for advice and criticism.

REFERENCES

During, C., Mitchell, K.J. and Lancaster, R.J. 1970. Management systems for growing Beef Cattle. New Zealand Beef Production Processing and Marketing. NZIAS. pp. 235-249.

Hutton, J.B. 1973. Developments in Nutrition and Management in relation to future of N.Z. Dairy Industry. Ruakura Conference. pp. 220-232.

Mitchell, K.J. 1966. Alternative Forage Crops for Livestock Feeding. New Zealand Agricultural Science **1**: 23-31.

Mitchell, K.J. 1969. Nitrogen and Storage Farming. New Zealand Agricultural Science **4**: 9-14.

Mitchell, K.J. 1974. Cost of forage compared with cost of pasture. Proceedings Agronomy Society of New Zealand **4**: 45-48.

Philpott, B.P., Greig, I.D. and Wright A. 1972. Some aspects of the economics of nitrogen storage farming in New Zealand. Agricultural Economics Research Unit Discussion paper No. 22.

Van Soest, P.J. 1963. Uses of detergents in the analysis of fibrous feeds. Journal of A.O.A.C. **64**: 829.

Appendix 1
DOUBLE FORAGE

Details of direct costs

	Lincoln	Otara
I Wheat		
Cultivation & sowing 2.5 hrs at $11	27.50	27.50
Seed 112 Kg/ha at 9.50/50 kg	21.28	21.28
Fertiliser N at 50 c	96.00	168.00
P at 30 c see text p.5	6.00	10.20
K at 15 c	26.00	45.50
Weed and Pest MCPA plus application	9.50	9.50
	$186.30	$282.00
II Maize		
Cultivation & sowing 2.5 hrs at $11	27.50	27.50
Seed 50 kg at 7.38/50 kg	7.38	7.38
Fertiliser N at 50 c	91.50	122.50
P at 30 c	10.20	13.79
K at 15 c	28.55	40.86
Weed and Pest: Atrazine	40.00	40.00
Diazinon	14.34	14.34
	$219.50	$266.40
III Irrigation 150 mm	16.31	
IV Harvest and delivery to storage at $6.66/tDM	260.00	366.00
TOTAL DIRECT COSTS	682.10	914.40
*V Interest and depreciation on feed handling and storage installation	241.00	310.00
*VI Labour: feed delivery and effluent disposal	35.00	45.00
TOTAL SPECIFIC COSTS	$958.10	1269.40
Total utilised DM produced	33930 kg	47850 kg
Cost/kg	2.82 c	2.65 c

* Based on Mitchell 1974 plus 10% for increase in costs since publication of his paper, plus adjustment for yield differences plus an allowance for effluent disposal costs.

Appendix 2
DIRECT COSTS (Grazed Pasture)

	Lincoln	Otara
Fertiliser 500 kg/ha 30% potash super	20.65	
1000 kg/ha 30% potash super		41.30
Haymaking : Yield 140 bales/ha		
Mowing & raking $12.50/ha x .34 ha	4.25	
x .21 ha		2.63
Baling 20c/bale	9.52	5.88
Cartage 12c/bale	5.71	3.53
Interest & depreciation on storage	6.66	4.12
Irrigation: To supply 300 mm water	32.62	
Subdivision fencing, water supply and reticulation access: interest, depreciation, repairs and maintenance	27.13	27.13
Weed and Pest control (Otara only)		4.94
	$106.54/ha	$89.53/ha
Utilised DM production	10200 kg/ha	12325 kg/ha
Cost per kg DM utilised	1.04 c	0.73 c