MAIZE AND SORGHUM SILAGE — U.S.A. AND U.K. EXPERIENCE

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PRODUCTION TRENDS

In a world context, maize ranks in importance with wheat and rice for grain production and is much more important than either as a forage crop. Maize growing in Europe has recently increased sharply, encouraged by the development of productive and relatively early hybrids and by the introduction of efficient methods of weed control. The expansion in maize grain production has been accompanied by a significant northward shift in areas of cultivation (Bunting and Gunn 1973). Seed companies in the U.S.A., well aware of these developments, are producing early maturing hybrids specifically for this market. These hybrids could prove useful here in New Zealand, particularly in our cooler climatic zones.

The area under maize in Europe is currently around 10% of that in the United States, with the bulk of production occurring in France and West Germany (Table 1). Perhaps the most significant trend to note in Europe is the very recent rise in silage production which may reflect EEC pressure for more internal primary production. This trend is likely to continue coupled with a swing away from N fertilized grass because of recent cost increases in artificial N. Maize at approximately 50 to 100 kg DM/kg N appears to be substantially more efficient in terms of dry matter produced/unit N than the 10 to 20 kg DM/kg N produced by pasture here in New Zealand (Holmes and Wheeler 1973).

In the Unites States, maize is currently grown on 30 million hectares, with roughly one-fifth of this area planted into sorghum (Table 2). Over the last ten or so years, there has been a small increase in maize and sorghum grain acreages and in sorghum for greenfeed, while there has been a decline in green feeding of maize. The largest proportionate change has been the increased production of maize silage with some swing away from sorghum silage. Currently, 80% of the silage produced in the U.S.A. is made from maize, while sorghum and pasture contribute 12 and 8% respectively (Anon 1974b). These figures do not include the production of lucerne haylage.

Maize silage production in different states of the U.S.A. varies widely, but Wisconsin, Minnesota and New York, which together form the group of prime dairying states, are among the top producers.

STOCK RATIONS

Silage systems developing in Europe have followed rather closely those already developed in the United States. These are aimed at maximizing animal production per unit feed cost and labour input and are based on detailed knowledge of animal requirements and the nutrient content and cost of forages and concentrates (Wilkinson and Kilkenny 1974).

Firstly, there is a clear definition of the nutrient requirements of stock and the separate animal functions

TABLE 1: Recent expansion of maize growing in north-western Europe [1]

	Grain		Area In 1000 ha		Silage	+	Greenfeed	
	1965	1970	1972	1973	1965	1970	1972	1973
France	865	1489	1877	1938	200	403	576	800
West Germany	26	96	118	105	100	190	285	346
Netherlands	0	1	4	3	3	6	30	50
Belgium					5	18	33	40
Switzerland	4	9	22	29	5	11	15	20
United Kingdom	0	0	2	1	1	2	6	8
	895	1595	2023	2076	314	630	945	1264

[1] Data from Bunting and Gunn, 1973.

TABLE 2: Recent trends in the planting of maize and sorghum in the United States [1]

	Maize			Area Harvested in 1000 ha / Sorghum		
	Grain	Silage	Greenfeed	Grain	Silage	Greenfeed
1962	22552	2914	626	4683	497	793
1966	23041	3206	394	5185	441	835
1970	23213	3311	342	5565	301	936
1972	23238	3350	217	5410	344	1016
1973	25048	3610	235	6416	341	873
1974	26384	4328 [2]	311	5632	302 [3]	879

[1] Data from "Agricultural Statistics" USDA, 1974.
[2] Actual production 111,250 x 10^3 tons.
[3] Actual production 7,223 x 10^3 tons.

TABLE 3: Comparison of sorghum and maize silages and the minimum % feed composition required by a dairy cow producing 20-30 kg/day of 4% fat milk. Data are from US National Academy of Sciences publications (Anon, 1971 a and b)

	Sorghum silage [a]	Maize silage [b]	Dairy cow requirement
Dry matter %	22.7	27.8	
Crude fibre %	32.2	27.2	13
Protein digestibility:	(34%)	(61%)	
Disgestible protein %	2.6	4.9	11.4
TDN %	57.9	70.7	65
Energy DE Mcal/kg	2.55	3.12	2.9
Minerals			
Calcium	c	0.25	0.47
Phosphorous		0.18	0.35
Potassium		0.28	0.10
Solium chloride		0.19	0.45
Sulphur		0.12	0.20

a Whole plant sorghum silage (NK 300) made at "late dough" stage.
b Whole plant maize silage made at mature "late dent" stage.
c Mineral composition of sorghum and maize silages are comparable.

for which rations must be programmed, i.e. maintenance, growth, fattening, milk production and growth plus fattening. Detailed information on all these functions for all important domestic animals have been published by the U.S. National Academy of Sciences and are used by farmers.

Secondly, farmers know the nutrient composition of their feeds. Once again, the U.S. National Academy of Sciences has published extensive tables giving data on all inportant crops at all stages of maturity whether fresh fed or stored. Where there are uncertainties, individual farmers can have their feed checked at USDA laboratories or by private firms.

Finally, nutritionally suitable lowest cost diets are constructed from a balance of roughages (maize silage, lucerne haylage etc.) and concentrates (grain, minerals etc.), with the type and amount of concentrate being the largest variable. Computer services are frequently available to aid in this programming.

Now we can look at the way in which maize and sorghum silages fit into this picture of programmed animal production using lactating dairy cows as an example. The nutrient content of typical well made maize and sorghum silages and the minimum nutrient requirements of a moderately high producing dairy cow are shown in Table 3. Sorghum silage is poorer quality than maize silage because it is lower in digestable protein, TDN and energy, and does not fully meet any of the animal's major nutritional requirements. Maize silage is deficient only in digestible protein and minerals. The quality limitations of maize silage are known by many New Zealand farmers, but the implications are not always understood as demonstrated by the many situations where overfat low-milk producing cows are seen after being fed substantial amounts of maize silage, particularly in late summer.

Overseas, maize is sometimes used to provide the whole dietary roughages, but this can lead to upsets in rumen functioning; particularly when cows are first given maize silage, after prolonged feeding ($>$150 days) and when nutrient requirements in the ration are not correctly balanced. Usually, legume or grass-legume haylage of good protein content and higher mineral content is used with maize silage to supply the roughage.

Concentrates of many types are used to achieve full dietary balance. In the U.S.A. concentrates make up 34% of the DM supplied the dairy cows, and their use has increased over the past 10 to 15 years as better technology has become available and as labour costs have demanded increased production/labour unit (Harrison 1968). Grain fed to dairy cattle has increased by 40%/head since 1960. A typical concentrate blend recommended for an all corn-silage roughage diet is shown in Table 4. Concentrates are not fed as a constant

TABLE 4: Typical concentrate ration [1] to be fed with maize silage to lactating dairy cows [2] (McCullough 1970)

Corn and cob meal	180 kg
Citrus pulp	270
Corn gluten feed	225
Soybean meal (50%)	225
Trace mineral salt	9
Dicalcium phosphate	9
Vitamin A	(3×10^6 units)

[1] Concentrate ration to make up 40% of DM intake.
[2] Dairy cows of 540 kg body weight producing 18 kg of 3.8% fat milk (maximum per cow DM intake of 16.5% Data are from Anon, 1974a.

proportion of diet, but are varied depending on the production potential of the animal. A typical recommendation from the U.K. relating to the lactation potential of dairy cows is shown in Figure 1.

The trend in the U.S.A. over the last 20 years of more tower silos, of increasing silo size, of gas tight storage and of automated loading and unloading is continuing; and good silage handling systems are now

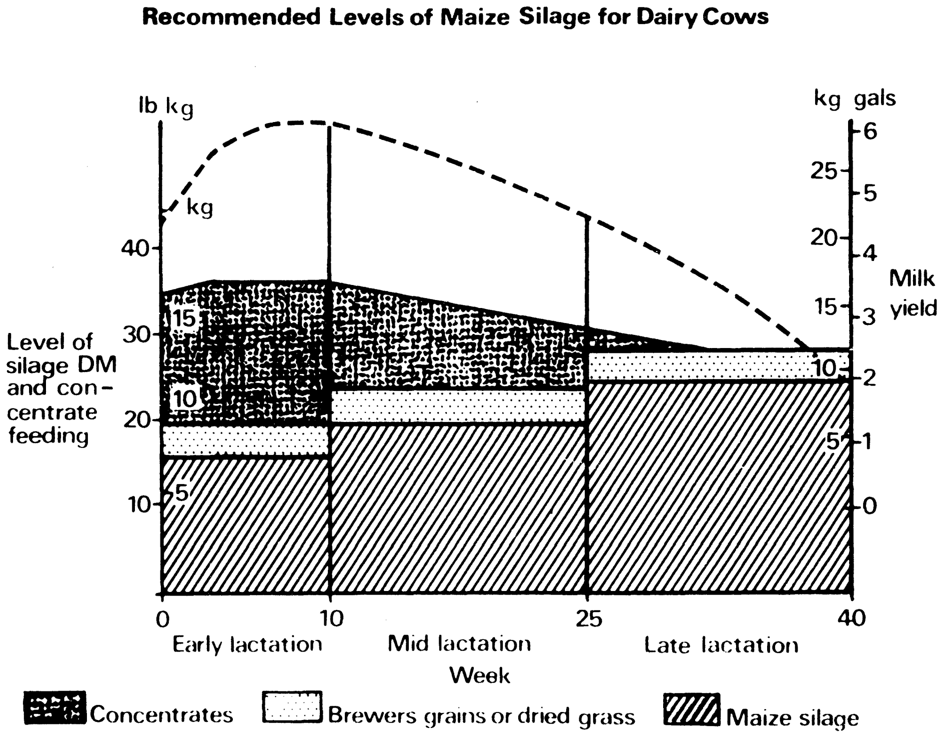

Figure 1. Levels of maize silage feeding in relation to stage of lactation. Data from Wilkinson and Kilkenny 1974.

Concentrates based largely on maize and soybean grain are also fed to beef cattle in the U.S.A., and in 1972 almost 80% of cattle marketed were grainfed to varying extents. One reason for this was the cheap cost of feed grains. Recently, costs of grain production have risen and foreign demands for grain have increased, thus forcing grain prices up sharply. Beef finishing feedlots were the most seriously affected because consumer resistance would not permit increased production costs to be passed on. A call for increased production of on-farm whole crop forages based on maize and legumes with less reliance on off-farm produced grain has recently been made in the U.S.A. (Hodgson 1974).

MECHANIZATION AND LABOUR INPUTS

Zero grazing systems based on conserved feeds are used extensively in the U.S.A. and are developing rapidly in Europe. There are several reasons for this. Temperature extremes in continental climates cause seasonal yield oscillations in permanent pasture production that are almost unmanageable and severe winters necessitate the housing of stock. There is demand for increased quality and quantity of animal products and a need to programme their supply for immediate local consumption. Finally, well made conserved feeds permit almost complete automation and mechanization of feed handling.

available for virtually any size or type of enterprise (Young 1971). Bunker silos are still used extensively, however, particularly in Canada and Europe. The popularity of maize and sorghum silage is partially dependent on their high yield potential, but also on the general quality of the silage they produced and the ease with which it can be handled.

When harvesting maize for silage, fineness of chop is an important factor in determining its subsequent quality. As gas tight silos become more common in the U.S.A., recommendations are to take maize to the late dent or glaze stage (35 to 40% DM) and chop to 6mm lengths. Finer chopping with recutter screens to 3mm substantially increased power requirements, does not increase grain digestibility and actually depresses fibre digestibility; presumably because smaller fibre particles can pass undigested through the rumen (Jorgensen and Crowley 1970). Under New Zealand conditions, where trench type silos are more common, aerobic oxidation at the working face can be a problem if the silage is not used rapidly. Shorter chop length and higher moisture content will both increase compaction and restrict oxygen movement into the face. As noted, however, shorter chopping increases power requirements and higher moisture will probably depress intake. More local research on these aspects of maize silage quality is required.

IMPLICATIONS FOR NEW ZEALAND

/. Maize silage and maize grain are major feeds in the Unied States for dairy and beef cattle and the use of maize in Europe in a similar role is rapidly increasing. A combination of factors appear to be responsible for this extensive use of conserved roughages and concentrates, namely, the need to house stock under climatic extremes; a demand for increased quantity and quality of animal products and the need to programme supply of these to large local markets.

In New Zealand, our pastoral based system produces marked fluctuations in seasonal DM yield despite our temperate maritime climate. Feed deficiencies in winter and summer affect the health and production of all stock and put serious pressure on the killing, processing and transport industries. We should make a serious attempt to integrate the most appropriate aspects of this in-depth overseas technology into New Zealand agricultural production systems of the future.

2. Production of our national dairy herd at around 300 lb fat/cow/year is not high by overseas standards and there is a wide spread of individual animal and herd performance within this country. If pedigree Friesians are used as an example (72/73 season), the record United States cow production in 365 days under concentrate feeding was2191 lb fat (1861 lb in 305 days); top New Zealand individual cow productions were around 1000 lb; the top six pedigree New Zealand herds averaged 660 lb in around 300 days, while the total New Zealand pedigree herd averaged 379 lb over 271 days. These large production differences among pedigree herds presumably means that the feeding of some stock is very poor.

Perhaps the management of a two- and sometimes three- component pasture system is not that simple. For example, summer over-grazing has been reported (Brougham and Jackman 1974) to reduce pasture yields by 33% largely through its effect on clover growth and N fixation. An adequate supple of quality conserved feeds from forage crops such as maize or sorghum should permit better pasture management practices to be followed and hence a substantial increase in total DM production per farm.

3, In the United States particularly, stock are fed for production on totally conserved feed diets (silage/haylage + concentrate) and on pasture and rangeland for maintenance. In Europe, stock are generally housed during winter, so again, these different types of diet are not normally mixed. The addition of conserved feeds (silages, haylages and concentrates) in varying proportions to a pastoral diet and the expectation of continuing high perfomance is not common practice overseas; yet we in New Zealand do this to some extent now and may wish to increase this practice in the future.

Patterns of volatile fatty acid production in the rumen differ under all grass and under concentrate feeding (Hutton, 1962), so the rumen and its complex microfloral population is unlikely to function at its best when faced with an ever changed intake of wet feeds, dry feeds, fibrous feeds and concentrates. More than just simple chemical analyses (fibre, protein etc.) will likely be required to optimize rumen functioning under these types of diet.

4. The most recent information I have been able to obtain from the New Zealand High Commissioner's office in London forecasts a doubling of the 1974 United Kingdom area in maize to 30.4 thousand hectares in 1975. This may represent the start of a swing away from N fertilized grass. Dry matter produced by maize/kg N appears to be substantially higher than that produced by grass. Protein levels in grass above those required by stock are expensive in the current cost situation. It will be interesting to follow these trends in other European countries over the next few years.

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