Integrating livestock and sugar-ethanol production and the dairy industry in Northland — a concept

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ABSTRACT

Arising from agronomic research into energy farming in Northland, a sugar-ethanol industry based on the crop sweet sorghum (*Sorghum bicolor*) has been proposed. The competitiveness of such an industry will probably depend on an integration with the processing functions of the dairy industry, and on the advantages gained from the increased animal production resulting from utilising the sugar-extracted crop residues.

A theoretical analysis of dairy, sheep, and fattening beef systems indicated that a limit of 10% of the farm cropped in sweet sorghum annually would optimise the production and use of sugar-extracted crop residues based on the use of most of the residues as silage. If such material could be converted directly to increase stocking rate, a substantial rise in net farm income was predicted from growing sweet sorghum for sugar.

Twenty Northland farmers were interviewed concerning on-farm aspects of this sugar industry concept. While limited in scope, this survey indicated a number of factors influencing further development of the concept, such as the importance of cropping contractors and independent technical advisors, and the doubt concerning the expected response from feeding crop residues to livestock.

INTRODUCTION

Past fluctuations in the supply and price of petroleum in New Zealand has stimulated research into the option of growing sugar crops for the production of ethanol fuel. Sweet sorghum is a summer annual crop which, by producing sugar for alcoholic fermentation and a high forage yield, could integrate with the pastoral farming of warm zone districts of New Zealand (Piggot, 1982 a). From the agro-industrial viewpoint, a system of on-farm, sugary-juice extraction and tanker collection for factory processing (Piggot, 1982 b) has the dairy industry as its model. Such a processing system could be integrated with milk processing since sorghum harvesting in autumn and winter occurs out of the main dairy production season. With on-farm sugar harvesting the farmer would be left with a large bulk of crop residue with some value as a ruminant feed. This concept is depicted in Fig. 1. The price paid at the farm gate for the sorghum juice would be sensitive to the price of imported cane sugar, other competitive sweeteners, or ethanol and may not necessarily be sufficient to stimulate farmer acceptance of sweet sorghum as a sugar crop only.

The objective of this paper is to indicate the potential benefits of using the sugar-extracted crop residue and also to indicate, from a limited survey of farmers, the likely prospects for this sugar-and-forage industry concept at the farm level.

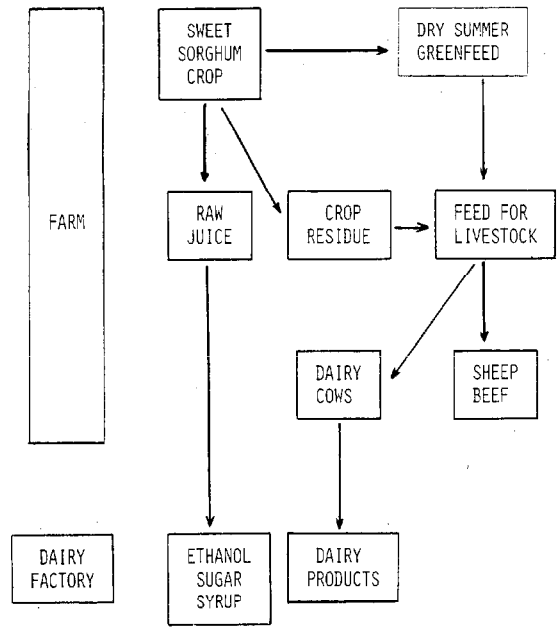

FIG. 1 The concept of a sugar-ethanol industry based on sweet sorghum and integrated with the dairy industry.

METHODS

Preliminary Systems Analysis

The production of sweet sorghum and the use of sugar-extracted crop residue was assessed for theoretical dairy, sheep and beef fattening farms using published New Zealand feeding standards (Scott *et al.*, 1979; Drew and Fennessy, 1980), information on Northland pasture growth, crop yield data from small plot trial work in Northland (Piggot and Farrell, 1980; Piggot, 1982 a, b; G. J. Piggot, unpublished data), and information from related sugar industry concepts overseas. The fresh or ensiled sweet sorghum residue was assumed to have an energy value equivalent to medium quality meadow hay and no protein or mineral deficiencies if fed as a supplement to pasture. It is important to note that this assumption has yet to be supported by direct evidence, although indirect evidence is available (e.g., Gourley and Lusk, 1978).

Farmer Interview

Twenty farmers (14 dairy, 4 sheep-beef, 2 mixed cropping) who were in contact with the Agricultural Research Division of M.A.F. for a variety of reasons were interviewed. A copy of the questionnaire and a summary of all responses are available from M.A.F on request.

The farmers were asked to respond to 34 questions following an explanation of the sorghum-sugar industry concept. The questions firstly concerned the soil type(s), arable suitability of the farm and farmer's arable skill, the farmer's impressions of the concept, the possible roles for, and values of the sugar extracted crop residues and the possible influence such material could have on farm productivity. Secondly, the farmer was asked to assume that a sugar industry as proposed was functioning and that he was about to grow a sweet sorghum sugar crop. He was then asked a series of questions concerning the choice of paddocks for cropping, the primary source of technical knowledge, the method of financing a crop, the methods of crop establishment and seasonal surveillance, the likelihood that the crop would be needed for summer greenfeed, the methods of sugar harvest, the method of storing and using sorghum silage, and the use of the land after the sugar harvest.

TABLE 1 Estimates of expected yields (t DM/ha) in climatically normal years of sweet sorghum grown from November to April and ryegrass-white clover pasture on an annual basis, from sites on 3 representative soils in Northland.

Location	Soil	Total crop yield	Pasture yield
Otakanini	loamy sand (YBS)	27	13
Ruatangata	volcanic (R and B loam)	20	11
Waimauku	clay (Northland YBE)	14	10

RESULTS AND DISCUSSION

Systems Analysis

Sweet sorghum crop yields from small plot trials at 3 sites are given in Table 1 (the quantity of sugar-extracted residue remaining after harvest would be approximately 85% of the total crop yield). The pasture yield estimates of Table 1 were obtained from longer-term measurements alongside the Otakanini and Waimauku sites (Piggot *et al.*, 1978; G. J. Piggot, D. M. Cooper and E. N. Honore, unpublished), while the Ruatangata estimate was assumed from other similar sites (e.g., Lambert, 1967; P. W. Shannon, unpublished). Clearly the sweet sorghum crop can provide substantially more total DM than the pasture even before considering the use of the sorghum land during winter and spring. However, conserving the sorghum crop residue as silage is the only practical method of utilising it efficiently.

For any farm growing both sorghum and livestock there will be a limit to the extent to which sweet sorghum can be integrated. Using a self-contained pastoral farm it can be calculated that a limit of 10% of the farm in sweet sorghum crop is an approximate optimisation, based on crop and pasture yield data (Table 1), the influence of land in crop on summer feed deficits, the use of the sugar-extracted crop residue as silage to supplement pasture, and on the harvest parameters provided in Table 2. Such an allocation of land to sweet sorghum cropping would increase the total pasture equivalent DM on the farm by approximately 8% before utilisation by livestock.

TABLE 2 Assumed values at harvest of some parameters of the sugar industry concept using sweet sorghum.

Total crop DM content	25%
Total green crop throughput capacity	8 t/h
Extraction efficiency: t juice/t green crop	25%
Tanker availability (raw juice cartage)	18,000 l/d
Sucrose concentration in raw juice	15%
Financial return/t sucrose in raw juice (1982)	$250

The use of the sorghum silage may be constrained by its relatively lower feeding value relative to pasture. Green or ensiled it could be used on Northland farms to supplement pasture in various ways:

Dairy — Maintaining summer milk production and off paddock wintering. Grass rationing in winter and early spring and lengthening the autumn grazing rotation.

Sheep — Flushing ewes and rationing grass from autumn to early spring.

Beef — Maintenance feeding in summer and autumn grass rationing from autumn to early spring.
The use of sorghum silage in any of these roles will have variable results on farm productivity and the prospect of any increase in net farm income is an assumption. Calculations converting the additional pasture equivalent DM to a stocking rate increase (of 8%) result in an increase of gross margin/farmed hectare of 11% on a dairy farm, 12% on a bull beef farm, 14% on a prime-lamb sheep farm and 16% on a prime beef farm (based on standard M.A.F. 1982 gross margins, 3 t sugar/ha sweet sorghum harvest, and an original stocking rate of 15 s.u./ha).

Farmer Interview

All farmers supported the research effort into the prospects of sweet sorghum as an ethanol-sugar crop and agreed with the hypothetical advantages of the concept. Each farmer had at least 10% of his farm capable of growing sweet sorghum although most admitted to little arable skill. When asked to assume a commitment to sweet sorghum cropping the likely reasons for such a decision varied from the cash benefits, the need to improve pastures or level paddocks, and the requirement for greenfeed or conserved residues as livestock feed. On 3 topics in the questionnaire the replies were similar. On most farms contractors would have been required to prepare the seedbed, sow the crop, harvest the sugar and prepare the silage; the source of technical knowledge relating to crop culture was seen as the role of an independent advisor (e.g., M.A.F. but not sugar company or merchants' representatives); the financing of crop establishment on a small proportion of the farm could have been handled within the farmer's own resources. Although the size of this survey limits any generalised conclusions, the relative unanimity of the farmers on these aspects suggests that a simple infrastructure partnership of farmer, contractor and independent advisor could run a sweet sorghum sugar industry at the farm level. The sugar processing company could control the flow of juice from farms by developing a relationship with the contractors and controlling the tanker collection.

The responses of the farmers to the suggested use of the green or ensiled sugar-extracted residue varied. However under certain conditions (e.g., price, availability) all farmers would be prepared to purchase silage on to the farm; thus the prospect of specialist sweet sorghum farms with an associated livestock-feed-supply function amongst a community of exclusively livestock farmers could be a possibility. The farmers surveyed would be feeding sorghum as a supplement to pasture and mainly during feed deficits in summer and autumn. Those that would feed sorghum silage during winter or spring possessed specialised facilities (e.g., pads or barns). Finally, the farmers were not convinced that the additions of sorghum silage would increase per animal or per hectare livestock production despite the theoretical indications. Actual evidence on the value of sugar-extracted sorghum silage in farm systems is clearly necessary.

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