A SURVEY OF RECENT WORK ON FORAGE BRASSICAS

[1]S. Gowers, [2]A.M. Nicol

[1]DSIR Crop Research
Gore
[2]Animal Science Department
Lincoln College
Canterbury

ABSTRACT

INTRODUCTION

The area of brassicas grown in New Zealand appears to have stabilised at around 140,000 ha, after showing a progressive decrease from 292,000 ha in 1960 (Table 1). National statistics are no longer available for brassicas, but the area of rape and swedes appears to have shown a slight increase at the expense of kale and turnips.

The increase in the rape area may be a consequence of the trend to the retention of a greater proportion of export lambs to heavier weights, and thus an increased requirement for summer forage crops. The fall in total forage brassica area is the result of a continuing trend to grass wintering of stock on silage and hay, with less reliance on supplemental forage crops.

It is almost ten years since a review of the husbandry of forage brassicas was last undertaken (Douglas, 1980; Nicol & Barry, 1980) and, in view of the apparent stability of the area grown, it is appropriate to summarise recent plant breeding, agronomic and animal production data on the forage brassicas.

PLANT BREEDING

Several new forage brassicas have been introduced recently in New Zealand, although most of them have been imported from Europe. The most significant new cultivar has been Tina swede, which is the first swede to combine dry-rot resistance and clubroot resistance (Lammerink & Hart, 1985). The excellent disease resistance allows Tina to be sown as a second brassica crop, where previously only kale could be used in this situation. Some farmers have now grown Tina in the same paddock for five or six years. In a first crop situation, however, Tina is lower yielding than most other cultivars. Tina also has low bolting requirements, and in a couple of years when there has been a cold autumn and a mild winter Tina has flowered prematurely. Although swedes do not usually cause nutritional problems, in this situation there is a possibility of greatly increased SMCO intakes, and a close watch should be kept on the situation.

The other recent release from CRD has been Kapeti kale. This cultivar was selected from Maris Kestrel for yield and clubroot resistance. From trials at Gore over the last ten years, Kapeti produced yields of 10 % higher than Maris Kestrel (Table 2). In the last two years, estimates of digestibility and wastage after sheep grazing have been made from the Gore trials (Armstrong & Gowers, unpub.). Medium stem had by far the largest amount of wastage, and it also had the lowest digestibility. When the results were combined, it was estimated that the other kales examined had over 70 % more digestible dry matter eaten than medium stem.

These trials, however, were carried out as first crops, and kale is usually grown in Southland as a second crop. The 1989 trial at Gore was carried out as a second crop, and Kapeti and Gruner held their positions relative to medium stem, but Kestrel, Merlin and Bittern were all more than 12 % lower yielding than medium stem.

However, the outstanding result from this utilisation study was the large amount of wastage with medium stem kale. Similar results were obtained by Banfield & Ovenden (unpublished) with dairy cattle; the mean utilisation for medium stem over three trials was 74 %, in comparison with Kestrel and Kapeti which had 85 % utilisation. In view of the results of Forss & Barry (1983) for nitrile production, perhaps it was fortunate that the sheep did not find this cultivar very palatable. The advice to farmers from this work must be ***not*** to grow medium stem.

No New Zealand cultivars of rape have been produced since 1980, when Wairangi was released,

Table 1. Area of brassica crops sown in New Zealand. (x ,000 ha, from New Zealand Agricultural Statistics).

	1960	1970	1980	1985	1990*
White turnips	77	60	50	48	45
Yellow turnips	20	15	9	6	5
Swedes	75	75	47	33	35
Rape	65	26	20	30	35
Kale	56	35	28	23	20
Total	292	210	153	139	140

* estimated

Table 2. Kale Trial Results from Southland trials. (Armstrong *et al.*, unpublished)

	Southland 1978-88 Yield, relative to medium stem	Wastage %	Gore 1978/88 DOMD %	Digestible DM eaten
Medium stem (12)*	100	63	74	100
Maris Kestrel (12)	106	31	77	194
Kapeti (11)	116	46	78	175
Merlin (10)	114	38	77	173
Bittern (8)	115	42	78	183
Gruner (4)	120	49	77	171

* number of times in trial.

which combined the characters of Rangi with clubroot resistance from Wye swede. However, a range of cultivars from overseas have been tried. Two of these, Arran and Winfred, have involved interspecific crossing to try to improve the digestibility and disease resistance of rape, and they have very distinctive leaf shapes. These two cultivars were among those tested by Banfield & Rae (1986), and Arran yielded well and appears to have good disease resistance. Other work to examine some of the new brassicas has been that of Percival *et al.* (1986) and Newton *et al.* (1987). However, irrespective of their yield and resistance, large areas of Rangi and Wairoa are still being grown, mainly because of their edibility, but also in the case of Wairoa because of its reputation for not needing to mature before feeding (Mortlock, 1972). A similar situation exists with white turnips; a wide range of material from overseas has been tried, but Green Globe and York Globe still dominate the market. The overseas cultivars were mainly of Dutch origin and, although they usually have good clubroot resistance, they also usually have a tankard type shape with a high proportion of the bulb underground and therefore wasted.

AGRONOMY

Not much agronomic work has been done on brassicas in recent years, although some work has been done on swedes in the United Kingdom and Ireland. Sowing date trials by Rodger *et al.* (1980) in Scotland, Munro *et al.* (1981) in England, and Barry & Storey (1985) in Ireland have shown that yields of swedes decrease as sowing is delayed after mid-May (mid-November for New Zealand). Work on weeding of swedes by Forbes (1985) showed that the best time for a single weeding was at six weeks after sowing. Earlier weeding allowed time for further weeds to become competitive, and later weeding allowed early competition from weeds to affect final yield.

Comparisons by Cromack (1984) showed that conventional Treflan incorporation was cheaper than the stale seedbed technique, which was cheaper than two or three passes of mechanical cultivation. The stale seedbed would only be economical when charlock or wild turnip was a serious problem. A single pass for mechanical cultivation would have been intermediate in price between Treflan and the stale seedbed costs. Calculations showed that the use of Treflan was justified with low weed populations, but that a wide spectrum of weeds at high populations were needed before it became profitable to combine Treflan and another complementary herbicide.

ANIMAL PRODUCTION

There are two areas where recent work has provided new data of animal performance on forage brassicas. These are animal responses to feed availability, and composition of carcass gain of lambs grown on forage brassicas.

(a) ***Feed allowance and post-grazing mass:*** The concept of feed allowance (kg DM on offer/head or /100kg/day) and post-grazing mass (kg DM/ha) as more useful indicators of likely levels of animal performance than 'utilisation', a term previously associated with the grazing of forage crops, has developed since Nicol & Barry's (1980) review of animal performance on forage crops.

Both Jagusch *et al.* (1981), who found turnips and rape to be satisfactory substitutes to pasture for 'flushing' ewes, and Barry *et al.* (1981a), in a study of the growth of young sheep on kale, provide useful data on the response of animal production to changing forage availability (Figure 1). These data show that because of the relatively high (> 5,000 kg DM/ha) pre-grazing mass of forage crops relative to pasture (1,500- 3,000 kg DM/ha), there is little increase in sheep performance at feed allowances above 2.5 - 3.0 kg DM/head/day with brassicas, compared with pasture where increases in intake may occur up to 4.0 - 5.0 kg DM/head/day. These modest allowances on forage crops are associated with much larger post-grazing mass (2.5 - 3.0 t DM/ha) than would be associated with the same allowance on pasture (1.0 - 1.5 t DM/ha), and the associated liveweight gains are double those on pasture. The acceptance that low post-grazing mass on forage brassicas is likely to be a common explanation for the relatively poor performance of stock on forage crops was not sufficiently highlighted by Nicol & Barry (1980).

None of the more recent evaluations of forage brassicas (Banfield & Rae, 1986; Percival *et al.*, 1886; Newton *et al.*, 1987) have included data on animal performance. In view of alleged differences in the acceptability of some varieties by stock, this lack of animal performance data is unfortunate.

(b) ***Carcass composition:*** In a comparison of lamb growth on rape, kale and fodder radish in Ireland, Fitzgerald & Black (1984) found that lambs grown on rape had fatter carcasses than those grown on the other crops, although it is not clear whether the higher fat content in the carcasses (29 vs 26 %) was simply a function of the higher carcass weight (17.7 vs 16.6 kg) or faster growth (150 vs 100 g/d) of the lambs grazed on rape. Anecdotal evidence in New Zealand also suggests that lambs finished on rape may be fatter. In a recent trial at Lincoln this was found not to be the case (Nicol & Fraser, unpub.).

Groups of ram lambs (20) were grown at a similar rate (165 g/day) on rape, lucerne and chicory for 64 days from mid- February. Liveweight change was controlled by adjustment, based on the liveweight gain over the previous week, of the fresh area of crop offered each week. The ground half carcasses of an initial slaughter group (12) and ten from each group at the end of the period were analysed for carcass fat and DM content. The results (Table 3) showed that, at a common liveweight gain, final carcass composition and the composition of the carcass gain was unaffected by the diet type. The fat content in the gain of these ram lambs (400 g/kg gain) is quite high, but less than the 580 g/kg gain in the wether lambs fed on forage crops in Ireland.

TOXIC FACTORS

With the decrease in area and importance of brassicas, there has been a decrease in brassica research in general, not only in New Zealand but elsewhere. The main exception to this has been the work carried out on SMCO (S-methyl cysteine sulphoxide) which has been shown to be responsible for causing kale anaemia or red water disease (Smith *et al.*, 1974). SMCO does not cause anaemia in non-ruminants, and may even be beneficial in lowering plasma cholesterol levels (Itokowa *et al.*, 1973). In the rumen, however, SMCO is converted to dimethyl disulphide, and this causes haemolysis.

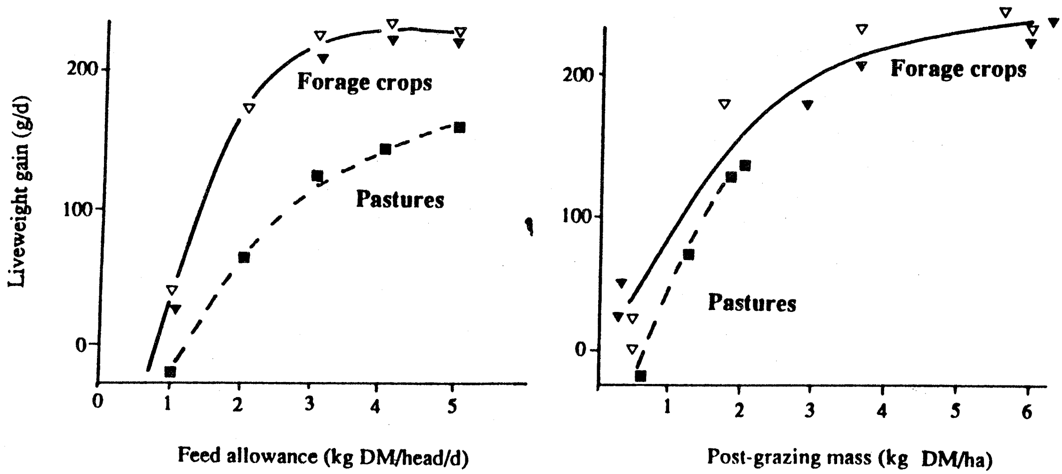

Figure 1: **Influence of feed allowance and post grazing mass of forage crops and pastures on sheep liveweight gain (from Jagusch *et al.* 1984)**

Table 3: **Liveweight and carcass composition of lambs grown at a similar rate for 64 days on rape, lucerne and chicory (Nicol & Fraser, unpublished).**

	Rape	Lucerne	Chicory	SE
Final fasted liveweight (kg)	37.8	37.4	37.4	0.94
Liveweight gain (g/d)	162	163	165	45
Carcass weight (kg)	17.7	16.4	17.4	0.45
Carcass weight gain (g/day)	78	66	83	35
Dressing out %	46.8	43.9*	46.4	0.41
Carcass components (g/kg)				
fat	249	244	236	18
water	520	532	528	42
protein + ash	231	224	236	17
Composition of carcass gain (g/kg)				
fat	426	413	371	40
water	371	402	391	27
protein +ash	203	184	237	24

* significantly different ($P < 0.05$)

All brassicas contain SMCO, and a survey of its distribution in brassica forage crops was carried out by Whittle *et al.* (1976). Kale was found to have the highest levels of SMCO, followed by rape and swedes, and then turnips with the lowest levels. These workers found that SMCO content increases as the plants get older and was associated with secondary growth and the development of flowers. They found flowers of kale to have twice the SMCO levels of whole plant samples, and as cattle have been observed to selectively graze the flowers of kale, this could lead to highly dangerous levels of intake.

SMCO content may be influenced by soils and fertiliser. McDonald *et al.* (1981) found that kale grown at a site with low S (4 ppm) had lower levels of SMCO than kale grown at high S (22 ppm). Applications of N caused an increase in SMCO, except at low levels of S, when an increase in N caused a decrease in SMCO. However, McDonald (1986) reported no correlation between SMCO and soil sulphate at levels ranging from 0.5 ppm to 18.8 ppm over eight sites. SMCO levels were however almost totally correlated with plant N, and significant increases in SMCO were found with application of N in all cases except the site where kale followed straight after grass.

Other factors affecting SMCO content are plant stand and cultivar. Whittle *et al.* (1981) found Maris Kestrel to have a lower content than the other marrow-stem and hybrid kales tested, and McDonald (1986) found that Bittern had lower levels than Maris Kestrel. McDonald also found that increasing plant density decreased the SMCO content, with whole plant levels of SMCO varying by up to 4 g/kg DM at different plant populations.

The anaemia caused by SMCO, due to the development of Heinz bodies in up to 40 % of red cells and a lowering of the haemoglobin concentration, is most severe after 4 weeks of kale feeding (Barry *et al.*, 1981a). There was considerable recovery in blood parameters and animal performance when feeding continued for more than 6 weeks, with apparent dry matter intake increases of 20-25 %. The depression of voluntary intake appeared to be the most important effect on liveweight gain caused by supplementation with synthetic SMCO (Barry *et al.*, 1982).

In some (Barry & Drew, 1978) but not all cases (Barry *et al.*, 1981) supplementation with amino acids helped alleviate the poor animal performance over the early kale feeding period. A further complication of SMCO consumption is the reduction of availability of dietary copper induced by the high sulphur intake. Liver and plasma Cu levels fall progressively as the length of feeding period increases, and supplementary Cu improved the liveweight gain of young cattle markedly (77 %) when kale was fed for long (> 6 week) periods (Barry *et al.*, 1981b).

The other major anti-nutritional factors in brassicas are the glucosinolates. These compounds are hydrolysed in crushed tissues by the action of myrosinase to produce thiocyanates, isothiocyanates or nitriles. Forss & Barry (1983) examined the nitrile production from glucosinalates of swedes and kale. Although swedes had quite high levels of glucosinolates, the nitriles produced from them were rapidly degraded in rumen fluid, whereas the nitriles produced from kale were not. Of the two kale cultivars tested, the leaves of Medium Stem had glucosinolate contents two to three times higher than those of Maris Kestrel. Also the proportion of glucosinolate converted to nitrile was higher with Medium Stem.

Rape generally has higher glucosinolate content than the other brassicas (Bradshaw *et al.*, 1984). The Swedish cultivar Samo, bred for lower glucosinolate levels, did have lower levels than the other Swedish cultivars tested by Gustine & Jung (1985). However, the two cultivars tested with the lowest levels of glucosinolates were the New Zealand cultivars Rangi and Moana, which were bred for palatabiltiy and aphid resistance.

FUTURE PROSPECTS

Herbicide resistance is one of the improvements that may be possible with brassicas in the near future. Resistance to atrazine has already been transferred to all the three main groups of forage brassicas (Ayotte *et al.*, 1987), but growth and yield are depressed because the resistance mechanism interferes with photosynthesis. Incorporation of Roundup and Glean resistance are objectives of the CRD biotechnology programme, and should be far more useful if there are no unforeseen side effects. Resistance to cabbage white butterfly and diamond back moth are also to be attempted.

Unfortunately, on the aspect of toxic factors, the prospects of any dramatic improvement appears slight in the near future. Factors controlling low SMCO content or low glucosinolates in the plant have not yet been obtained. However, if they were obtained in one of the forage brassicas, it should now be possible to transfer them to any of the other species. The transfer between rape and kale can now be made and the transfer of characters between turnip and rape is relatively easy (Gowers, 1982). One improvement that is already under way is the incorporation of aphid resistance from kale into rape (Quazi, 1986).

A range of self-incompatibility genes has already been obtained in *Brassica napus* (Gemmell *et al.*, in press) and these could be used in several ways to produce hybrids of swedes or of rape (Gowers, 1986). The main aim of the CRD swede breeding programme is to produce a hybrid with Tina to combine disease resistance with higher yield. With the increase in new techniques available, therefore, there are prospects of improving all types of forage brassicas. However, with the long generation time of forage brassicas and the present economic climate, it could take some time before these improvements become available.

REFERENCES

Ayotte, R., Harney, P.M. & Souza-Machado, V. 1987. The transfer of Triazine resistance from *Brassica napus* to *Brassica oleracea* I. Production of F_1 hybrids through embryo rescue. *Euphytica 36*, 615-624.

Banfield, R.A. & Rea, M.B. 1986. A comparison of six cultivars of forage rape over a range of sowing dates in Canterbury. *Proceedings of the Agronomy Society of New Zealand 16*, 49-52.

Barry, T.N. & Drew, K.R. 1978. Responses of young sheep grazing swedes, turnips and kale to intraperitoneal and oral supplementation with DL methionine. *New Zealand Journal of Agricultural Research 21*, 395-399.

Barry, P.J. & Storey, T.S. 1985. Effect of time of sowing on the yield and quality of swedes. *Irish Journal of Agricultural Research 24*, 221- 228.

Barry, T.N., McDonald, R.C. & Reid, T.C. 1981a. Nutritional evaluation of kale (*Brassica oleracea*) diets. 1. Growth of grazing lambs as affected by time after introduction to the crop, feed allowance and intraperitoneal amino acid supplementation. *Journal of Agricultural Science, Cambridge 96*, 257-267.

Barry, T.N., Reid, T.C., Millar, K.R. & Sadler, W.A. 1981b. Nutritional evaluation of kale (*Brassica oleracea*) diets. 2. Copper deficiency, thyroid function and selenium status in young cattle and sheep fed kale for prolonged periods. *Journal of Agricultural Science, Cambridge 96*, 269-282.

Barry, T.N., Manley, T.R. & Millar, K.R. 1982. Nutritional evaluation of kale (*Brassica oleracea*) diets. 4. Responses to supplementation with synthetic SMCO. *Journal of Agricultural Science, Cambridge 99*, 1-12.

Bradshaw, J.E., Heaney, R.K., Macfarlane-Smith, W.H., Gowers S., Gemmell, D.J. & Fenwick, G.R. 1984. The glucosinolate content of some fodder brassicas. *Journal of the Science of Food and Agriculture 35*, 977-981.

Cromack, H.T.H. 1984. The economics of weed control in fodder root crops. *Crop Protection in Northern Britain 1984*, 202-209.

Douglas, J.A. 1980. Yields of crops for forage and fodder. In *Supplementary Feeding* (eds. Drew, K.R. & Fennessey, P.F.) *Occasional Publication, New Zealand Society of Animal Production 7*, 1-47.

Fitzgerald, J.J. & Black, W.J.M. 1984. Finishing store lambs on green forage crops. *Irish Journal of Agricultural Research 23*, 127-136.

Forbes, J.C. 1985. Weed-crop competition studies in swedes. I. The effect of weed removal on crop yield. *Annals of Applied Biology 106*, 505-511.

Forss, D.A. & Barry, T.N. 1983. Observations on nitrile production during autolysis of kale and swedes, and their stability during incubation with rumen fluid. *Journal of the Science of Food and Agriculture 34*, 1077-1084.

Gemmell, D.J., Bradshaw, J.E., Hodgkin, T. & Gowers, S. 1989. Self-incompatibility in *Brassica napus*: seed set on crossing 19 self-incompatible lines. *Euphytica 42*, 71-77

Gowers, S. 1982. The transfer of characters from *Brassica campestris* to *B. napus*. *Euphytica 31*, 971-976.

Gowers, S. 1986. Possible Applications of self-incompatibility in the production of *Brassica napus* cultivars. *Agronomy Society of New Zealand Special Publication 5*, 63-66.

Gustine, D.L. & Jung, G.A., 1985. Influence of some management factors on glucosinolate levels in Brassica forage. *Agronomy Journal 77*, 593-597.

Itokowa, Y., Inove, K., Sasagawa, S. & Fujiwara M. 1973. Effect of S-methylcystine sulfoxide, S-allycysteine sulfoxide and related sulfur containing amino acids on lipid metabolism of experimental hypercholesterolemic rats. *Journal of Nutrition 103*, 88.

Jagusch, K.J., MacLean, K.S. & Dow, B. 1984. The efficacy of substituting field crops for pasture for flushing ewes. *Proceedings of the Agronomy Society of New Zealand 14*, 57-59.

Lammerink, J. & Hart, R.W. 1985. 'Tina', a new swede cultivar with resistance to dry rot and clubroot. *New Zealand Journal of Experimental Agriculture 13*, 417-420.

McDonald, R.C. 1986. Factors affecting variability of SMCO in kale. *Cruciferae Newsletter 11*, 122-125.

McDonald, R.C., Manley, T.R., Barry, T.N., Forss, D.A. & Sinclair, A.G. 1981. Nutritional evaluation of kale diets. 3. Changes in plant composition induced by soil fertility practices, with special reference to SMCO and glucosinolate concentrations. *Journal of Agricultural Science, Cambridge 97*, 13-23.

Mortlock, C.T. 1975. An Assessment of some forage crops in south Canterbury. *Proceedings of the Agronomy Society of New Zealand 5*, 17-19.

Munro, I.A., Dickinson, A.B. & Scourey, L.R.K. 1981. Effect of time of sowing and powdery mildew on yield of swedes. *Experimental Husbandry 37*, 16-20.

Newton, S.D., Chu, A.C.P., Sollitt, D. & Lynch, T.J. 1987. Growth and regrowth of some brassica forages over summer in the Manawatu. *Proceedings of the Agronomy Society of New Zealand 17*, 21-24.

Nicol, A.M. & Barry, T.N. 1980. The feeding of forage crops. In *Supplementary Feeding* (eds. Drew, K.R. & Fennessey, P.F.) *Occasional Publication, New Zealand Society of Animal Production 7*, 69-106.

Percival, N.S., Bond, D.I. & Hunter, R.M. 1986. Evaluation of new forage brassica cultivars on the central plateau.

Proceedings of the Agronomy Society of New Zealand ***16***, 41-47.

Quazi, M.H. 1988. Interspecific hybrids between *Brassica napus* and *B. oleracea* developed by embryo culture. *Theoretical and Applied Genetics* ***75***, 309-318.

Rodger, J.B.A., Lang, R.W., Chapman, W. & Donald, A.H. 1980. The effects of date of sowing swedes in East Scotland. *Experimental Husbandry* ***36***, 27-33.

Smith, R.H., Earl, C.R., & Matheson, N.A. 1974. The possible role of S-methylcysteine sulphoxide in kale poisoning in ruminants. *Biochemistry Society Transactions* ***2***, 101-104.

Whittle, P.J., Smith, R.H. & McIntosh, A. 1976. Estimation of S-methylcysteine sulphoxide (kale anaemia factor) and its distribution among brassica forage crops. *Journal of the Science of Food and Agriculture* ***27***, 633-642.