# YIELDS AND SUGAR CONTENTS OF SUGAR BEET AND FODDER BEET CULTIVARS

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## ABSTRACT

Two experiments at Templeton Research Station compared a total of seven sugar beet and twenty two fodder beet cultivars during the 1979-1980 season. Fresh weight yields of roots of sugar beet ranged from 50 to 63 t/ha, whilst for fodder beet the range was 50 to 130 t/ha. Dry matter and total sugar percentages were generally higher for sugar beet than fodder beet, ranging from 22.0 to 24.9% and 15.4 to 19.5% respectively for sugar beet, and from 12.3 to 22.8% and 8.4 to 16.6% respectively for fodder beet. Sugar yields were similar for both types of beet, ranging from 7.8 to 11.5 t/ha for sugar beet, and 6.4 to 11.4 t/ha for fodder beet. Reducing sugars were only 1.1 to 4.3% of the total sugars in the roots of both beet types.

## INTRODUCTION

There has been sporadic interest in sugar beet for a sugar industry in New Zealand since 1870, and this has resulted in numerous trials in many parts of the country over the past century. The most recent of these have been in Otago and Southland in the 1960's (Greenwood, 1980) and in mid Canterbury in the 1970's (Drewitt, 1976).

With the rapid increase in oil prices in the 1970's, renewed interest in sugar beet arose from its potential as a source of ethanol for use as a liquid fuel for motor vehicles (Kardos and Mulcock, 1977). Gillespie (1977) claimed that sugar beet was economically more attractive than potatoes or cereals for ethanol production in New Zealand.

More recently, Dunn *et al.* (1978) have suggested that fodder beet, currently grown on a small scale for stock feed (Steele and Martin, 1979), would produce considerably higher yields of fermentable sugars than sugar beet. Subsequent evaluation of the potential for energy farming in New Zealand (NZERDC, 1979) has, on the basis of yield forecasts given by Dunn *et al.* (1978), claimed that fodder beet was by far the most economically attractive crop for energy farming.

As Drewitt (1979) had found little difference in yields of total sugars between a sugar beet and two fodder beet cultivars, it was decided to investigate the comparative yields of a range of sugar beet and fodder beet cultivars to test the proposition of Dunn *et al.* (1978). Two experiments were sown at Templeton Agricultural Research Station in the spring of 1979, each containing a number of sugar beet and fodder beet cultivars. These included most of those fodder beet cultivars commercially available in New Zealand plus all the fodder beets and some of the sugar beets recommended by the National Institute of Agricultural Botany in the United Kingdom (Kimber, D.S., pers. comm.).

## MATERIALS AND METHODS

Soil type was a Templeton silt loam and Experiment 1 followed a cereal trial, Experiment 2 a fallow after green beans. On both experiments fertilizer was broadcast before planting at the rate of 43 kg/ha nitrogen as calcium ammonium nitrate, 20 kg/ha phosphorous and 0.75 kg/ha boron as boron superphosphate, and 40 kg/ha potassium as potassium chloride. Phorate (1 kg/ha) was applied with the fertilizer. Lenacil (2.4 kg/ha) was applied and incorporated with dutch harrows immediately before planting.

Experiment 1, sown on 30 September, contained 21 cultivars of beet, and Experiment 2, sown on 19 October, 12 cultivars. The cultivars, Vytomo, Kyros, Monoblanc and Yellow Daeno, were sown in both experiments, although, in the case of Kyros, different seed lines were used. There were 4 replicates of a randomized block design in each trial, and plot sizes were 8m x 2.5m. The experiments were sown with a precision drill, and plant spacing was 500mm between rows and 125mm between plants within the row. Hand thinning after emergence increased the within-row spacing to 250mm, giving a planned plant population of 80,000 plants/ha. Singling was not attempted.

Both experiments were flood irrigated on 20 December and 30 January. Hand hoeing between the rows to control weeds was carried out at intervals through the summer.

Harvesting took place from 17 to 20 June. The harvest area was 5m x 1.5m (3 rows). Plants were hand lifted, counted and topped to remove all green material. Fresh weights of tops and roots were recorded, and a sample of 6 roots from each plot washed and reweighed to correct for dirt. Three sample beets were quartered longitudinally and 52g of gratings taken off the cut surfaces. Total and reducing sugars from the gratings were measured using the automated colormetric method of Quin *et al.* (1980). About 1.5 kg of the 6 beets were sliced into pieces less than 15mm thick and oven dried for two days at 80°C.

## RESULTS

Results are given in Table 1 for Experiment 1 and in Table 2 for Experiment 2.

### Plant Population

Hand thinning resulted in 13 of the 21 cultivars in Experiment 1 and 6 of the 12 cultivars in Experiment 2 being less than 15% different from the target population of 80,000 plants/ha. Meka (Experiment 1) and Svalofs Nova II (Experiment 2) had large multigerm seeds, which were too large for the sowing belts used in the drill, resulting in lesser numbers of seeds being planted. The fodder beet cultivars with plant populations over 92,000 plants/ha were planted with rubbed and graded seed and produced a significant number of doubles or trebles. One sugar beet, Bush Mono G. was sown with bare seed which was too small for the seed belts, resulting in poor regulation of seed flow.

**TABLE 1: Plant number and fresh weight, and root dry weight and sugar yields from Experiment 1.**

| Cultivar | Plant Population ('000/ha) | Tops Fresh Weight (t/ha) | Roots Fresh Weight (t/ha) | Root DM% | Root DM (t/ha) | Total Sugars as % Root FW | Root Sugar Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Sugar Beets | | | | | | | |
| Monoire | 82 | 21.7 | 58.6 | 24.5 | 14.4 | 18.7 | 11.0 |
| Monotri | 89 | 23.8 | 58.8 | 24.9 | 14.7 | 19.5 | 11.5 |
| Nomo | 88 | 22.6 | 62.4 | 23.3 | 14.5 | 17.6 | 11.0 |
| Vytomo | 87 | 22.7 | 51.2 | 23.5 | 12.1 | 18.4 | 9.4 |
| **Mean** | **87** | **22.7** | **57.8** | **24.1** | **13.9** | **18.6** | **10.7** |
| Fodder Beets | | | | | | | |
| Hugin | 76 | 24.4 | 77.4 | 19.4 | 15.0 | 14.0 | 10.8 |
| Kyros | 78 | 17.9 | 74.3 | 17.6 | 13.1 | 13.1 | 9.8 |
| Majoral | 140 | 23.4 | 77.5 | 16.0 | 12.3 | 11.5 | 8.9 |
| Meka | 60 | 17.8 | 50.9 | 19.9 | 10.0 | 14.5 | 7.4 |
| Monara | 82 | 16.7 | 79.4 | 15.4 | 12.1 | 10.5 | 8.3 |
| Monoblanc | 85 | 28.3 | 74.8 | 19.3 | 14.4 | 14.3 | 10.6 |
| Monobomba | 84 | 18.0 | 68.8 | 17.4 | 11.9 | 12.0 | 8.2 |
| Monorosa | 75 | 19.5 | 57.8 | 19.1 | 11.1 | 14.1 | 8.2 |
| MonoVal | 139 | 20.6 | 86.3 | 17.3 | 14.9 | 12.3 | 10.6 |
| Monovert | 106 | 18.1 | 71.3 | 18.4 | 13.2 | 13.3 | 9.5 |
| Peramono | 83 | 13.7 | 76.7 | 12.3 | 9.4 | 8.4 | 6.4 |
| Peroba | 87 | 16.7 | 73.6 | 15.6 | 11.5 | 10.8 | 7.9 |
| Poly Groeningia | 136 | 18.3 | 73.1 | 19.3 | 14.1 | 14.4 | 10.6 |
| Solanka | 76 | 15.9 | 69.7 | 17.2 | 12.0 | 12.1 | 8.5 |
| Solobeta | 119 | 16.5 | 51.7 | 22.8 | 11.8 | 16.6 | 8.6 |
| Vital Daehnfeldt | 151 | 18.0 | 63.6 | 19.6 | 12.5 | 14.5 | 9.2 |
| Yellow Daeno | 131 | 21.7 | 87.1 | 17.4 | 15.2 | 12.2 | 10.6 |
| **Mean** | **100** | **19.1** | **71.4** | **17.9** | **12.6** | **12.9** | **9.1** |
| LSD 5% | 13 | 5.6 | 12.9 | 1.4 | 2.5 | 1.3 | 2.0 |

**Tops**

Fresh weight yield of tops, i.e. crowns, petioles and leaves, were higher in Experiment 2 than in Experiment 1. The sugar beets tended toward the upper end of the range of weight of tops, probably reflecting a greater proportion of crown included in the tops, whereas, in some of the fodder beets, the shape of the root and location of leaves resulted in very little crown being included in the tops. However, Monoblanc had the second highest top fresh weight of all beets in Experiment 1 and the highest in Experiment 2.

**Roots**

Root yields of the 4 cultivars common to both experiments were higher in Experiment 2 than in Experiment 1, although the relatively larger increase in yield of Kyros may be partly due to different seed lines being used in the two experiments.

(a) *Sugar Beet*

The 7 sugar beets had fresh root yields of between 50 and 62 t/ha. Dry matter percentages were all above 22%, and root dry weights ranged from 11.4 to 14.7 t/ha. Total sugars as a percentage of the fresh weight of roots ranged from 15.4% to 19.5% with a mean of 17.7%. Total sugar yields were 7.8 t/ha for Kawerenta but ranged up to 11.5 t/ha for the other cultivars with a mean of 10.2 t/ha. Reducing sugars were about 2.2% of total sugars, so that, for the highest yielding sugar beet, Monotri, there was less than 270 kg of reducing sugars in the 11.5 t/ha of total sugar.

(b) *Fodder Beet*

Only one fodder beet cultivar, Solobeta, equalled the sugar beet cultivars in root dry matter percentage and sugar percentage. However, this cultivar had lower fresh root and total sugar yields than most of the sugar beets.

Six other cultivars, Hugin, Meka, Monoblanc, Monorosa, Poly Groeningia and Vital Daehnfeldt, had over 19% dry matter and over 14% total sugars in the roots. Apart from Monorosa and Meka, all had sugar yields somewhat similar to the sugar beets.

Of the remaining 15 fodder beets, 6 cultivars, Capax, Kyros (in Experiment 2), Monoval, Monriac, Oscar and Yellow Daeno, had root fresh weights of 83 to 130 t/ha, but low dry matter and sugar percentages resulted in sugar yields similar to those of the sugar beets. Compared to this group, Monovert had lower root fresh weight, but higher sugar percentage resulting in similar sugar yields. The other 8 cultivars, Majoral Monara, Monobomba, Monorosver, Peramono, Peroba, Solanka and Svalofs Nova II, had, by a combination of low fresh root yields and low sugar percentages, relatively low yields of total sugars.

Reducing sugars made up 1.1 and 4.3% of total sugars in the fodder beet cultivars, similar to the level in sugar beet.

**TABLE 2: Plant number and fresh weight, and root dry weight and sugar yields from Experiment 2.**

| Cultivar | Plant Population ('000/ha) | Tops Fresh Weight (t/ha) | Roots Fresh Weight (t/ha) | Root DM% | Root DM (t/ha) | Total Sugars as % Root FW | Root Sugar Yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Sugar Beets | | | | | | | |
| Bush Mono G | 171 | 50.2 | 60.7 | 23.7 | 14.5 | 17.9 | 10.8 |
| Kawagigamono | 80 | 45.7 | 62.3 | 22.0 | 13.8 | 16.1 | 10.2 |
| Kawerenta | 77 | 35.9 | 50.2 | 22.6 | 11.4 | 15.4 | 7.8 |
| Vytomo | 91 | 38.2 | 57.2 | 22.9 | 13.1 | 17.8 | 10.1 |
| **Mean** | **105** | **42.5** | **57.6** | **22.8** | **13.2** | **16.8** | **9.7** |
| Fodder Beets | | | | | | | |
| Capax | 116 | 35.3 | 129.5 | 12.9 | 16.6 | 8.4 | 10.8 |
| Kyros | 78 | 30.9 | 90.8 | 16.8 | 15.2 | 12.2 | 10.9 |
| Monoblanc | 83 | 47.0 | 79.5 | 18.9 | 15.1 | 14.4 | 11.4 |
| Monorosver | 83 | 26.1 | 74.7 | 17.3 | 13.1 | 11.3 | 8.4 |
| Monriac | 109 | 33.5 | 83.4 | 17.5 | 14.5 | 12.8 | 10.7 |
| Oscar | 99 | 30.9 | 92.1 | 15.9 | 14.5 | 10.9 | 9.9 |
| Svalofs Nova II | 54 | 19.9 | 58.3 | 16.1 | 9.4 | 11.0 | 6.4 |
| Yellow Daeno | 116 | 31.4 | 94.3 | 17.0 | 16.1 | 11.1 | 10.5 |
| **Mean** | **92** | **31.9** | **87.8** | **16.6** | **14.3** | **11.5** | **9.9** |
| LSD 5% | 19 | 9.5 | 22.4 | 1.6 | 3.7 | 1.7 | 2.7 |

## DISCUSSION

These are the results from one season and site, and it is possible that different results may have been obtained with different cultivars or on other sites or in other years. For example, the 4 cultivars common to both experiments gave higher yields in Experiment 2, which was sown 19 days after Experiment 1. This contrasts with the trend of decreasing yields with later sowings (Drewitt, 1976; Greenwood, 1980), and was probably due to differences in site history and soil fertility. However, the relationships between sugar beet and fodder beet yields reported here are consistent with those reported from Denmark by Claridge (1955) and those found at Winchmore by Drewitt (1979).

Overall yields and sugar percentages of sugar beet were similar to the average obtained at Winchmore over a number of years (Drewitt 1976; 1979). They are also consistent with results from Tasmania, on the basis of which, a potential commercial fresh root yield for a sugar beet industry in that state of about 50 t/ha has been suggested, with an average sugar yield of 8 to 9 t/ha (Department of Agriculture, 1979). Greenwood (1980), reviewing sugar beet trials in Otago and Southland, suggested similar potential commercial yields for South Otago.

Some of the fodder beet cultivars in these two experiments were also grown by Dunn (1976), Pratt and Dunn (1976), and Wrightson NMA (Quoted in Dunn *et al.,* 1978). Generally, fresh weights of roots reported here were lower and dry matter percentages higher than in these earlier trials, resulting in similar dry matter yields. Yields of Yellow Daeno and Monobomba in these experiments were equal to the highest yields recorded for these cultivars in a farm survey the previous year (Steele and Martin, 1979), but considerably lower than those anticipated by Dunn *et al.* (1978).

The results indicate little difference in total sugar yields between sugar beet and fodder beet, there being 6 sugar beets and 11 fodder beets yielding between 9 and 11.5 t/ha of total sugar. Also the reducing sugar level in both types of beet was very low. Thus the suitability of the two types of beet for sugar or alcohol production will depend on factors other than yield. These may include:

1. agronomic characteristics such as ease of establishment, resistance to pests and diseases, and ability to tolerate adverse conditions such as drought or cold.
2. ease of harvesting, which will be affected by root size, shape, evenness and height out of the ground. Low dry matter beets may be more susceptible to damage during harvesting.
3. keeping quality of the beets in clamps, both in cold weather in the winter and warm weather in the spring.
4. transport costs to the factory. On the basis of these results, it would cost over twice as much, on a per hectare basis, to transport Capax than Monotri for the same yield of sugar. The importance of this will depend on the relationship between transport and other costs, and on the distance from field to factory.
5. ease of processing and extraction of sugars or alcohol, and the level of impurities (not measured in these experiments) which may affect the extraction or the quality of the final product.

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