SWEET CORN AS A PROCESSING CROP IN THE MANAWATU

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ABSTRACT

Sweet corn has been grown commercially for processing in the Manawatu since 1977, initially by Premier Foods Ltd., and subsequently by J. Wattie Canneries Ltd. High land prices and competition from other high value crops in the Poverty Bay and Hawke's Bay have contributed to the increase in production in the Manawatu from 2,400 tonnes in 1980 to 8,000 tonnes in 1986. At present, this represents about 25% of the company's total sweet corn production.

The performance of sweet corn grown in the Manawatu and Poverty Bay over this period was compared using factory records, and prospects for increasing the level of production in the Manawatu are discussed. Results from a 14 cultivar trial are then used to summarise some of the factors which need to be considered when matching cultivars to the processor's needs and to the environment. These factors include yield and stability, crop maturity, quality and uniformity and agronomic suitability to the area.

Yields and variability of yield in Manawatu and Poverty Bay are comparable, but there is a major difference between districts in the length of the effective season. Lower summer temperatures in the Manawatu, combined with later warming of the soil in the spring reduces the average duration of the harvesting period to 6 weeks, compared with 10 weeks in Poverty Bay. Unless cultivars which mature even earlier can be found for the Manawatu, increases in crop area will need to be accompanied by an increase in factory processing capacity.

Additional Key Words: Yield, season-length, temperature, cultivars.

INTRODUCTION

Sweet corn has been grown for processing in the Manawatu since 1977, initially by Premier Foods Ltd., and subsequently by J. Wattie Canneries Ltd., hereafter referred to as Watties. The crop is currently processed into a single product, frozen free-flow whole kernel corn, most of which is exported. Growers' gross income from this crop was about $1 million in the 1985/86 season, from a harvest of 8,000 tonnes of ears.

In the past, the majority of sweet corn for processing has been grown in Poverty Bay. In the 1979/80 season, Watties processed 21,700 tonnes in Poverty Bay compared with 2600 tonnes in Hawke's Bay and 2400 tonnes in the Manawatu. However, rising land values and competition from other high value crops in Poverty Bay and Hawke's Bay have contributed to the subsequent increase in the area of the sweet corn crop grown in the Manawatu. The area planted in the Manawatu has increased from 139 ha in the 1979/80 season to 450 ha in the 1985/86 season, so that currently 25% of Watties' sweet corn production is based in the Manawatu. In 1983 Watties ceased growing sweet corn for processing in the Hawke's Bay.

In this paper, we use factory records to compare the performance of sweet corn grown for processing in the Poverty Bay, Hawke's Bay and Manawatu districts, and thus gain some insight into the suitability of the Manawatu environment for this crop. Using the results of a cultivar trial, we also consider some of the factors which must be taken into account when choosing cultivars for a particular district.

MATERIALS AND METHODS

Factory Records

Information supplied by Wattie's from their Gisborne, Hastings and Feilding factories summarized details from individual crops grown within seasons. These included cultivar, sowing date, harvest date, kernel moisture at harvest, area harvested and total yield.

Cultivar Trial

The trial was conducted near Feilding during the 1983/84 season on a Te Arakura fine sandy loam soil. For each of two sowing dates, a randomized complete block design was used with three replications. The second sowing was situated on the north-western (windward) side of the first. Of the 14 cultivars used, 11 were of the *su* genotype and 3 (Sweet Perfection, Marika and Temptation) were *sh2* genotypes.

Seed was sown with a Nodet-Gougis commercial planter, modified to prevent mixing of seed between plots. Within each replicate, each plot of a cultivar was planted in two 30 m long rows at a spacing of 24 cm within the row and 76 cm between rows, giving a sowing rate of 54,000 seeds/ha. Fertilizer (12:10:10 NPK) was drilled with the seed at a rate of 250 kg/ha, weed control was achieved with pre-emergence application of Bladex and Lasso at recommended rates and greasy cutworms were controlled with post-emergence application of Ambush at recommended rates.

Sowings were made on 15 November and 13 December 1983 to represent the early and late periods of the usual 6-week sowing season.

Silking was recorded every second or third day as the percentage of plants per plot with visible silks. From these records dates at which 50% of the plants per plot had silked were estimated. After silking samples of 4 ears per plot were taken at intervals to assess the rate of decline of kernel moisture, so that the harvest date could be determined. Ears in this study include the rachis (cob), kernels and husk leaves.

When the mean kernel moisture was expected to be 72% (wet-weight basis) for a cultivar, ears were hand-picked from 80 fully bordered plants in the central 10 m portion of each 30 m plot. Husks and kernels were removed mechanically, and kernel samples were oven dried at 85 °C to constant weight to determine kernel moisture. The overall kernel moisture at harvest ranged from 69 to 78 percent among individual plots, with a mean of 74 percent.

When producing whole kernel corn, the fraction of the ear that is kernel is of economic importance to the processor and is referred to as the "recovery". It is usually assessed after the kernels have been processed. In this trial, recovery was based on the fresh weight of unblanched kernels as a percentage of the fresh weight of the unhusked ear.

To enable yield comparisons to be made at a standard 72% kernel moisture, total fresh weight of the kernels was increased or decreased by 450 kg/ha for each percent point that the kernels from the plot were below or above 72%. This change in kernel fresh weight was then incorporated directly into ear yield and recovery calculations, as at this stage changes in the fresh weights of ears are almost entirely due to changes in the fresh weight of kernels. The factor of 450 kg/ha was determined from data obtained from ears before harvest, and subsequently confirmed for the cultivar Reliance in a trial plot grown at Plant Physiology Division in the 1984/85 season.

Height measurements were made after silking on 10 plants in the central portion of each plot. Heights were measured from the soil surface to the ligule of the flag leaf, and to the node of insertion of the primary ear. The number of rows of kernels per ear were determined on 10 ears taken from each plot in the second replicate. After the emergence of the flag leaf the total number of leaves per plant was recorded for 10 plants per plot.

RESULTS AND DISCUSSION

Comparisons among Districts

The climate in the Manawatu in summer is characterised by lower temperatures and a higher windrun than in Poverty Bay and Hawke's Bay, but has comparable rainfall and raised-pan evaporation (Tables 1 and 2).

As a consequence of these lower temperatures, sweet corn crops take longer to reach maturity in the Manawatu. For example, Reliance, an early maturing cultivar, takes 5 days longer, on average, to reach 72% kernel moisture at Hastings than it does in Gisborne, and 12 days longer at Feilding (Brooking and McPherson, unpublished data). This, coupled with later soil warming in the spring (Table 2), results in a shortening of the length of the effective season and is reflected in the average pattern of sowing and harvesting in the three districts (Table 3).

Despite lower temperatures in the Manawatu, overall yields have been comparable with crops in Poverty Bay, whereas yields in Hawke's Bay have been, on average, about 20% lower (Table 4). These overall yields incorporate different combinations of sites, cultivars and products, but where comparisons were possible for the same cultivar and product, these trends held up. On average, the Manawatu environment appears to be as favourable as that of Poverty Bay as far as sweet corn yields are concerned.

TABLE 1: A summary of the major environmental factors during the sweet corn growing season.*

Nov to March Mean	Manawatu	Hawke's Bay	Poverty Bay
Temperature (°C)	16.3	17.1	17.4
Windrun (km/day)	355	175	244
Days with gusts >63 km/h	34.5	17.0	19.5
Rainfall (total mm)	310	290	355
Raised pan evaporation (total mm)	709	678	753

* No single recording site includes all of these measurements, so the summary for each district includes data from several sources.

TABLE 2: Mean monthly air and 10 cm soil temperatures in the 3 districts.*

Month	Manawatu		Hawke's Bay		Poverty Bay	
	air °C	10 cm soil °C	air °C	10 cm soil °C	air °C	10 cm soil °C
October	12.4	12.3	12.6	12.4	13.4	14.1
November	14.0	14.5	14.6	15.7	15.2	17.0
December	15.8	16.9	16.5	18.1	17.0	19.6
January	17.5	18.4	18.0	19.4	18.3	20.5
February	17.6	17.7	17.9	18.7	18.5	19.9
March	16.5	16.1	16.3	16.2	17.0	17.5

* Kairanga, Havelock North and Manutuke recording sites, respectively.

TABLE 3: Average planting and harvesting periods in the 3 districts. (Poverty Bay 1974-1985; Hawke's Bay 1979-1983; Manawatu 1980-1985).

	Planting period	Days	Harvesting period	Days
Poverty Bay	17 Oct-28 Dec	72	26 Jan-4 Apr	68
Hawke's Bay	22 Oct-22 Dec	61	9 Feb-6 Apr	56
Manawatu	3 Nov-17 Dec	44	23 Feb-9 Apr	45

TABLE 4: Mean seasonal yields (t/ha).

Season	Manawatu	Hawke's Bay	Poverty Bay
1979/80	17.8	11.6	15.2
1980/81	15.6	13.0	13.9
1981/82	15.8	12.8	17.1
1982/83	14.2	11.6	14.3
1983/84	19.2	-	21.5
1984/85	19.2	-	17.5

Reasons for the consistently lower yields obtained in Hawke's Bay are not obvious from the climatological data (Table 1). It is possible that soils of the Hawke's Bay have a lower water holding capacity, which may lead to more frequent water stress in this district.

Stability of Yield

From a commercial point of view, variation in yield from year to year is as important as the actual yield. Over the 6 year period from 1980 to 1985, mean seasonal yields in the Manawatu and Poverty Bay showed a similar range of variation (Table 4), though the coefficient of variation (12 and 17%, respectively) suggests that yields were more stable in the Manawatu.

This period includes 1982/83, which was one of the worst summers in the Manawatu, characterised by cool temperatures, high winds and an early killing frost on 31 March. During this season, grain yields of maize were 40% below normal in the Manawatu (Eagles and Fordyce, 1984), but most sweet corn crops appear to have escaped the worst effects of this season (Table 5). This difference relates to the timing of each crop's development. Sweet corn is harvested at a relatively early stage of kernel development (72% kernel moistures), which normally occurs in the Manawatu about 30 to 40 days after flowering, while grain maize normally takes about 70 to 90 days from flowering to reach maximum grain dry weight (Brooking, unpublished).

TABLE 5: Cultivar Yields for six sweet corn cultivar grown in the Manawatu over 5 seasons (t/ha).

Cultivar	1980/81	1981/82	1982/83	1983/84	1984/85
NK 51036	14.1	14.5	13.8	14.7	17.2
NK 195	15.6	14.0	-	-	-
Rosella 422	19.6	18.2	16.7	21.1	-
Golden Treasure	17.7	19.2	-	18.7	-
Midway	15.5	14.1	8.5	-	19.1
Reliance	-	-	16.3	18.5	19.8

In the 1982/83 season, the early planted, early maturing cultivar, NK51036, had been completely harvested by the time the killing frost occurred, and yields were comparable with those of the previous two seasons (Table 5). The later planted, medium maturity cultivar, Rosella 422, was harvested from 1 to 20 days after the frost and showed a slight reduction in yield compared with the previous two seasons. The late planted, late maturity cultivar, Midway, was at a very early stage of kernel development when the frost occurred (estimated silk dates for these crops were mid to late March), and yields were

TABLE 6: Ear yield, kernel yield, recovery and kernel cost for 14 sweet corn cultivars grown in the Manawatu, 1983/84.

Cultivar	Ear yield[a] (tonnes/ha)	Kernel yield[a] (tonnes/ha)	Recovery (%)	Kernel cost[b] ($/tonne)
Rosella 422	25.8	11.0	42.7	236
Fanfare	24.6	10.7	43.7	230
76-2681	32.4	10.2	31.7	316
Reliance	23.9	10.0	43.2	232
GH 1983H	26.8	9.5	35.3	286
Topaz	29.2	9.3	31.7	316
Midway	28.1	8.8	31.5	318
XPH 2553	24.0	8.8	36.6	275
XPH 2566	22.2	8.5	37.9	265
Marika	22.3	8.1	36.5	275
Sweet Perfection	23.6	7.6	32.8	309
Temptation	29.2	7.6	26.4	382
NK 51036	20.8	6.6	31.5	318
Mevak	18.7	5.9	31.7	319
Mean	25.0	8.8	35.2	291
LSD 5%	3.3	1.2	2.7	23
Date 1	26.7	9.3	35.1	294
Date 2	23.4	8.3	35.4	289
LSD 5% for dates	2.8	ns	ns	ns

[a] Yields adjusted to 72% kernel moisture, at a density of 54,000 plants/ha

[b] Assuming a payment to growers of $100 per tonne of ears.

reduced by about 45%. This reduction was comparable with that of the maize crops grown for grain.

Cultivar Choice

Attributes to be considered in assessing the suitability of a cultivar for a region include yield and maturity, together with various agronomic, morphological and quality considerations. Results from the 1983/84 field trial are used to illustrate these points.

Yield: The relevant measure of yield for a sweet corn crop depends on the end product. For corn-on-the-cob, yield of the whole ear is appropriate, whereas for whole kernel and cream-style products the yield of shelled kernels is appropriate.

Yields of unhusked ears ranged from 18 to 32 t/ha (Table 6). Yields of ears were significantly lower in the second planting, and there was a significant positive correlation between ear yield and crop duration ($r^2 = 0.75$). Because of significant cultivar differences in recovery, the ranking of cultivars for shelled kernel yield differed markedly from that for whole ear yield (Table 6). In contrast to the ear yields, there was no significant effect of planting date on kernel yield, and no significant correlation between yield and crop duration. This indicates that there is little need to use late maturing cultivars to obtain high yields of kernel in this environment.

As the current system of payment to growers is on a picked ear basis, recovery is an important factor determining the cost to the factory of the raw material for whole kernel processing. Assuming a payout of $100 per tonne of ears to the grower, the gross cost to the processor per tonne of shelled kernels can range from $230 to $382 (Table 6).

Maturity: Cultivar maturity (days from sowing to 72% kernel moisture) ranged from 115 to 141 days (Table 7). No cultivars matured significantly earlier than Reliance, which is the earliest cultivar currently grown by Watties in the Manawatu and Poverty Bay. Planting date had no significant effect on the growing period of crops, though this result probably occurred because of the actual planting dates chosen and the subsequent temperature environments experienced by the plants. Plants in the first planting took about 7 days longer to flower, but this was balanced by a shorter period from flowering to 72% kernel moisture (Table 7). With different planting dates or in a different season, a response to planting date could be expected.

Leaf number per plant was not significantly affected by planting date (Table 7), but cultivar differences were marked, ranging from 13 to 18 leaves per plant. The number of days from sowing to 72% kernel moisture was significantly related to leaf number ($r^2 = 0.64$), with an average increase in this season of 4 days per extra leaf.

Lodging: Wind-run was relatively low in the 1983/84 season (February/March average of 270 km/day, compared with a 10-year mean for this period of 332 km/day), so the potential for wind damage was not fully realised. Lodging occurred only in the second planting, with XPH 2566 and Temptation being particularly susceptible, averaging 60 and 35% root lodged plants respectively.

TABLE 7: Time from sowing to silking and harvest (days), and final leaf number.

Cultivar	Sow to harvest	Sow to silk	Silk to harvest	Leaf number
Marika	115.3	75.7	39.7	13.1
Reliance	116.5	79.7	36.8	14.0
Sweet Perfection	116.8	78.3	38.5	13.6
Mevak	117.0	83.5	33.5	15.3
NK 51036	121.0	84.7	36.3	15.8
GH 1983H	123.3	86.0	37.3	15.6
XPH 2553	123.8	86.8	37.0	15.3
Fanfare	126.2	85.3	40.8	14.1
XPH 2566	127.0	88.2	38.8	17.9
Rosella 422	130.0	86.8	43.2	17.7
Topaz	134.8	92.0	42.8	17.2
Midway	135.7	93.2	42.5	18.1
Temptation	136.8	94.2	42.7	18.1
76-2681	141.3	95.5	45.8	17.0
Mean	126.1	86.4	39.7	15.9
LSD 5%	2.4	1.8	1.7	0.3
Date 1	125.8	90.0	35.8	16.0
Date 2	126.5	82.8	43.6	15.9
LSD 5% dates	ns	1.8	1.4	ns

As is evident from these results, stage of crop development, cultivar and weather are all interacting factors involved in lodging. As a result of these interactions, selection of cultivars for resistance to lodging cannot be readily achieved from a single planting. Furthermore, because sweet corn grown for processing is planted over an extended period, the opportunity for wind damage in at least some of the crops is greater than in grain maize crops, where a single planting is usually made.

Height: Plant, and ear heights are important considerations, as ears borne too close to the ground are difficult to harvest mechanically. There was considerable variability in cultivars for both plant and ear height (Table 8), and there was a large and significant effect of planting date on both characters. Averaged over all cultivars plant and ear heights were respectively 34% and 48% greater in the second planting. As leaf number per plant was not influenced by planting date (Table 7), this increase in plant height was presumably achieved through longer internodes, or more internodes undergoing expansion in the second planting. Further work would be required to determine the extent and generality of this response in sweet corn.

Tillering: Throughout development, the second planting was more vigorous than the first, producing a much taller crop which tillered freely. In the first planting, only the taller, later maturing cultivars approached complete canopy cover. By contrast, in the second planting the shortest cultivars (Marika and Sweet Perfection) were the only ones not to attain a full canopy. These observations suggest that higher plant populations could be used to advantage in this environment, with consequent suppression of undesirable tillers and secondary ears.

TABLE 8: Plant height and number of rows of kernels per ear.

Cultivar	Height to flag leaf (m)	Height to primary ear node (m)	Kernel row number
Marika	1.13	0.33	13.3
Sweet Perfection	1.18	0.39	13.9
Reliance	1.31	0.43	17.9
Mevak	1.47	0.49	16.8
Fanfare	1.50	0.47	18.3
XPH 2553	1.57	0.44	17.4
GH 1983H	1.58	0.55	17.5
NK 51036	1.59	0.53	13.4
Temptation	1.66	0.77	15.8
Rosella 422	1.76	0.67	16.3
XPH 2566	1.77	0.71	17.1
Midway	1.79	0.64	16.4
76-2681	1.83	0.66	18.1
Topaz	1.89	0.74	15.6
Mean	1.57	0.56	16.0
LSD 5%	0.04	0.03	1.0
Date 1	1.35	0.45	
Date 2	1.80	0.67	
LSD 5% dates	0.04	0.01	

Quality: In this trial, the only direct measure of quality made was the number of rows of kernels per ear. Currently market preference is for ears with a large number of rows and small kernels (B.P. Price, pers. comm., 1984). Rosella 422 is a 16-rowed cultivar known to have unacceptably large kernels, and several cultivars had significantly more rows of kernels per ear (Table 8), and hence were more acceptable.

Uniformity: Ideally a single crop of sweet corn should at harvest have ears of uniform size and at the same stage of development. Observations made after the ears had been de-husked demonstrated marked differences in ear uniformity between cultivars. For example, Mevak and NK 51036 were of comparable maturity, but ears of Mevak were more consistent in size and stage of development than those of NK 51036. In the second planting date, the later maturing cultivars (Topaz etc.) were more variable than when compared with the first planting date, and problems such as incomplete pollination at the tip of the ear became apparent.

CONCLUSIONS AND RECOMMENDATIONS

Comparison of factory records from Feilding and Gisborne shows that similar yields of sweet corn are obtained in both districts. Variability of yield among seasons is also comparable between these districts, suggesting that despite generally lower temperatures, the Manawatu is as suitable as Poverty Bay for sweet corn production.

There is a major difference between these districts in the length of the effective season, however, and the harvest period is on average three weeks shorter in the Manawatu. Even ignoring the influence of the rate of soil warming on the length of the effective season, cultivars maturing at least 12 days earlier than Reliance would be necessary to make the length of the effective season in the Manawatu comparable with that in Poverty Bay. These cultivars are not currently available, so any increase in crop production in the Manawatu would need to be matched by an increase in processing capacity in the factory.

Cultivar choice inevitably involves compromise between consumer requirements, processing requirements at the factory and agronomic performance. Cultivar trials provide a baseline of information from which such decisions can be made, and a wide selection of cultivars is available for testing, particularly from the U.S.A. and Canada. Continued screening for cultivars suitable for the Manawatu is recommended to minimize delays in gaining the benefits of any new, superior cultivars, and to enable rapid responses to changing market requirements. Emphasis should be placed on cultivars of a maturity equal to or earlier than Reliance, with good resistance to lodging. To maximize product uniformity, a single-eared, non-tillering single-cross hybrid would be desirable. Consideration should also be given to supersweet varieties of the *sh2* genotype. These have both higher endosperm sugar levels and a longer period of acceptable quality than the traditional *su* genotypes (Boyer and Shannon, 1984).

Further work on response to plant density is also recommended. Sweet corn plant densities in the Manawatu (50-55,000 plants/ha) are below those commonly practised for grain maize in this region (60-75,000 plants/ha), and higher plant densities have the potential to increase both yield and uniformity of ears.

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