Commercial maize production in New Zealand

A. K. Hardacre, K. I. Sinclair and M. P. van Tilberg[1]

DSIR Crop Research, Private Bag, Palmerston North
[1] DSIR Crop Research, Cronins Road, RD 1, Pukekohe

Abstract

Over the past decade, the area sown in maize in New Zealand has stabilized at about 17,000 ha which produces about 160,000 tonnes of grain per year. From 1940 to the present, grain yields have risen from about 3.8 to over 9 tonnes/ha, an average gain of more than 0.1 tonnes/ha per year. In part, this increase has been due to improvements in management, soil fertility and weed control. However, genetically based improvements in the hybrids sown have also contributed significantly to increases in crop yield. Yield data from experimental plots and best farms suggest that yields of up to 1 third greater than the New Zealand average are possible in most years.

For grain yields to be high and reliable, a hybrid must be adapted to the environment in which it is to be grown. The hybrid must reliably reach a harvestable grain moisture content during the available growing season, its resistance to disease, pests and lodging must be good and the overall yield potential must be high. Different hybrids are used in different districts within New Zealand, the hybrids chosen represent a compromise between maximum economic return, not necessarily yield and maximum reliability given the climatic differences which occur among seasons and locations.

Additional key words: *hybrids, economic return, management, soil fertility, weed control*

Introduction

Maize is a versatile crop which can produce an excellent green feed, silage or high yields of grain. It is the third most important grain crop in New Zealand after barley and wheat with production of about 160,000 tonnes of grain per year. Generally production and consumption within New Zealand are balanced, although up to 50,000 tonnes/year have been imported and up to 30,000 tonnes/year exported. The main use for the grain is for pig and poultry feeds (70%) while the remainder is utilised by the wet and dry milling industries which produce a range of flours, starches and sugar syrups. The wet milling industry also yields a valuable food oil.

In this paper I will discuss the history of maize production in New Zealand with special attention to factors affecting changes in grain yield. The yields and hybrids used for grain production over the past decade will be examined more closely and reasons for changes in the hybrids being offered for sale will be discussed.

History

Maize was almost certainly introduced into New Zealand in the late 18th century by the explorers Marion du Fresne and Captain James Cook (Rhodes and Eagles 1984). It was rapidly incorporated into, and became an important part of Maori agriculture. The Maoris used it either as a fresh product, much in the same way sweet corn is used now, as a dried storable grain or as a wet stored fermented product called Kaanga-Wai or rotten corn (Bansal and Eagles, 1984; Yen, 1959). It is likely that the open pollinated varieties used by the Maori agriculturalists are related to varieties from eastern South America and the southern USA (Rhodes and Eagles, 1984). Several distinct types have been identified including the Marigold and Motiti varieties with large yellow kernels, Mahia and Horsetooth with large white kernels and a Sweet corn variety with black kernels.

Maize has also played an important part in recent agricultural production. Between 1900 and the early 1940's, about 4,000 ha yielding an average of about 3 tonnes/ha of grain was grown (Bansal and Eagles, 1984). Most of this was grown on the warmer east coast of the North Island, particularly in the Bay of Plenty and Poverty Bay regions. Production during this period was based on open pollinated varieties including Marigold, Horsetooth, Early Butler and Motiti. These varieties are all late maturing and would not have been suited to cooler regions of New Zealand. There is no evidence

over the 40 year period to 1940 that yields were improved by either better management techniques or by selection for improved ecotypes within the varieties used.

In the 1920's breeders in the United States found that hybrid maize varieties could dramatically increase grain production compared to the previously used open pollinated varieties. Hybrids were first grown commercially in New Zealand in the 1940s and by the 1960s dominated grain maize production. However, the increasing use of hybrids over this period did not result in a dramatic increase in grain production per hectare (Figure 1). The reasons for this are not clear, possibly the class of land used for maize production and other management practices could not realize the greater yield potential of hybrids.

From the early 1960's to the 1970's, both production per unit area and the area sown in maize increased rapidly to a peak of about 29,000 ha yielding an average of 7.4 tonnes/ha in the 1976-77 season (Figure 1). The large increase in maize production over this short period occurred largely in the Hawke's Bay and Waikato regions with later expansion into the Manawatu. This was due to a combination of improved economic returns from maize compared with other arable cropping and most importantly, with dairy farming. The availability of improved hybrids, the development of effective chemical weed control and improved fertilizer management undoubtedly contributed to the increase in production per unit area.

Since 1980 the area for grain production has stabilized at about 17,000 ha while production has risen from 7-8 tonnes/ha to about 9 tonnes/ha. This is close to the New Zealand average increase in production of 0.1 tonnes/ha/year between the 1940s and the 1980s and is similar to the world average for the 1980s (Hallauer *et al.*, 1988). It is difficult to separate genetically based improvements to yield over 1980-90 period from improvements due to better management practises, variation due to environmental changes and changes in the land classes used for maize production. However, data from our own field trials, where management has been consistent from season to season, suggest that

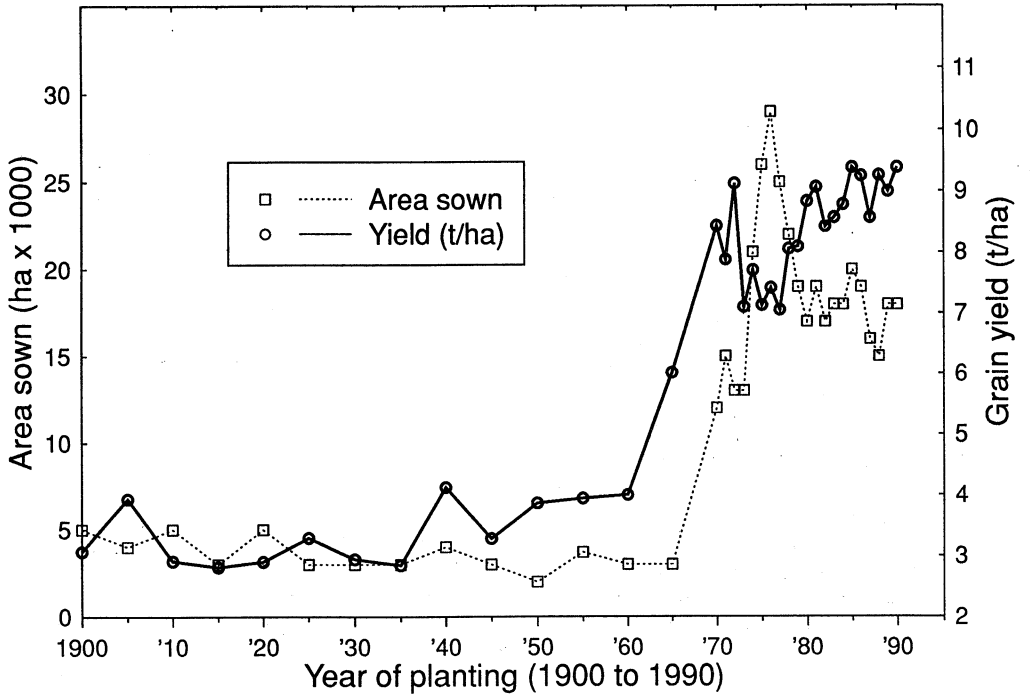

Figure 1. The area sown (ha) and grain yield (t/ha) of maize in New Zealand between 1900 and 1990. (Anon. 1983-91).

genetically based improvements in yield of 0.1 tonnes/ha/year are possible.

Yield Potential of Hybrids

Comparisons of yield data from our trials with the average grain yields for New Zealand between 1980 and 1989 (Table 1) show that commercial grain yields are generally below the potential of the hybrids grown. Yields from our experimental plots in the Manawatu are about a third greater than the NZ average in most years. The exception was the 1982-83 season which was very cool during the December-February period in the Manawatu. However, grain yields obtained for top farmers (data not presented) were similar to yields from our experimental plots. This suggests that by improving management practices, the genetic potential of the hybrids available may be realized and hence economic returns to growers increased.

Factors Affecting Hybrid Acceptance

The hybrids used for grain production in New Zealand have changed many times since the introduction of Pfister 360 in the 1940s. The average 'life' of a hybrid in the market place is about seven years, although this varies considerably. Some hybrids are sold for only one season while others, such as Pioneer 3901 in the Manawatu and PX74 in the Poverty Bay region, have been important for grain production for more than 10 years.

Table 1. Yields of the best hybrids in DSIR trials in the Manawatu and average maize yields in New Zealand from 1980 to 1989.

Year	Best Yield Manawatu (t/ha)	NZ Average (t/ha)	NZ Average as % of Best Manawatu
1980	14.7	8.8	59.9
1981	14.4	9.1	63.2
1982[1]	7.9	8.3	105.1
1983	13.1	8.8	67.2
1984	13.6	9.8	72.1
1985	12.9	8.7	67.4
1986	14.2	9.7	68.3
1987	11.3	9.3	82.3
1988	15.3	8.6	55.9
1989	13.5	9.3	68.9

[1] Cool growing season in the Manawatu.

All the hybrids used for grain production in New Zealand originate in the US. However, due to genotype by environment interactions, hybrids which have been successful in New Zealand, may not be widely grown in other areas of the world. Pioneer 3901 is an example of this. It is not known why some hybrids are widely adapted and others only produce well in a narrow range of environments or only in some seasons. Genotype by environment interaction is, however, an important factor when seed companies decide the market potential of a hybrid.

The major factor determining which hybrid to grow is the duration of the season. Hybrids which are capable of growing throughout the period when temperatures are favorable generally produce higher yields than those which mature earlier. However, hybrids which do not mature within the available season may suffer serious yield losses and require costly grain drying. This effect will be exacerbated in cooler seasons. In general, the East Coast and Northern regions of New Zealand are suitable for later maturing hybrids, such as PX74, while in the Manawatu region, earlier maturing hybrids such as Pioneer 3901 are popular. In other areas 'local' hybrids which offer some regional advantage may be preferred. The best hybrid for a region, therefore represents a compromise between maximum economic return, not necessarily yield, and maximum reliability given the climatic differences which occur from season to season.

Breeders continually aim to produce new hybrids with improved performance and hence economic returns. The results of their efforts are seen in the large number of commercially available hybrids tested in our hybrid evaluation program over the past decade (Table 2). Many of the hybrids have only appeared on the market during the last three years. It is expected that many of these will just as rapidly disappear as on farm performance is established.

The factors determining the replacement of one hybrid by another in the commercial environment are difficult to assess accurately, as yield is the only character for which statistics are readily available. Although it is certain that yield is very important in ensuring the acceptance of a hybrid, hybrids with lower yields but other desirable features such as low grain moisture content at harvest and improved disease or lodging resistance may offer economic advantages and therefore be preferred by growers.

The compromises which have been made between yield, grain moisture content at maturity and lodging are illustrated in Table 3. Over the period shown in this table, P3901 became one of the most popular hybrids grown in the Manawatu, although it only achieved top

Table 2. Some of the hybrid maize varieties commercially available over the past decade.

	Hybrid[1]	Use[2]		Hybrid	Use		Hybrid	Use
1	Pioneer 3180	c,n	14	PX 15	o	27	XL 80	c
2	Pioneer 3184	c,n	15	PX 39	o	28	XL 82	o
3	Pioneer 3189	c,n	16	PX 49	o	29	DK 529	o
4	Pioneer 3362	c,n	17	PX 74	c	30	PAC 40	o
5	Pioneer 3379	c,n	18	PX 75	o	31	PAC 42	c,n
6	Pioneer 3475	c,n	19	PX 442	o	32	PAC 50	c
7	Pioneer 3540	o	20	PX 610	o	33	PAC 52	c,n
8	Pioneer 3544	o	21	PX 9199	o	34	PAC 100	o
9	Pioneer 3551	o	22	PX 9540	c	35	PAC 110	c
10	Pioneer 3585	c,n	23	XL 35	o	36	PAC 009	c
11	Pioneer 3591	o	24	XL 45a	o	37	G4334	c
12	Pioneer 3709	c	25	XL 54	o	38	CG1	c
13	Pioneer 3901	c	26	XL 72aa	o	39	J7770	c

[1] Prefixes to hybrid numbers: Pioneer, Pioneer Brand; PX, Northrup-King; XL and DK, De-Kalb; CG, Corson Grain; J, Jacques;

[2] Use: c = current o = obsolete n = hybrids less than 3 years in the market

yields in three of the eleven years shown. In 1980 and 1981, P3901 did not produce grain yields as high as PX610 or XL45a, two of the hybrids it was destined to replace. However, it's lower grain moisture content at maturity compared with PX610 (22% cf. 33%) and reduced lodging compared with XL45a (0% cf. 10%) conferred sufficient economic advantage to ensure it replaced these hybrids for grain production, a dominance it maintained with P3709 for a decade. P3709 is another interesting hybrid. In our trials it seldom exceeded the yield of P3901 and generally had a higher grain moisture content, yet it remained a very popular hybrid in the Manawatu. This happened because it is considered to produce higher grain yields than P3901 under adverse conditions. Thus the conservative hybrid P3709 is sometimes preferred to the opportunistic hybrid P3901.

From Table 3, it might have been expected that P3551, which also has low lodging scores and low grain moisture in our trials, would replace P3901. This has not occurred and discussions with growers suggest that lodging on some soil types increases sufficiently to reduce acceptance of this hybrid. P3901 will probably be replaced in the near future as production of the inbred parents in the US ceases and new hybrids offer higher yields with lower or comparable grain moisture.

Table 3. Yield, moisture and lodging for trials in the Manawatu of hybrids with the greatest yields and yield of P3901 as a % of these hybrids.

	Year / Hybrid[1]										
	1980 PX610	1981 XL45a	1982[2] P3709	1983 P3901	1984 P3901	1985 P3901	1986 P3551	1987 P3511	1988 PAC50	1989 P3475	1990 P3551
Yield (t/ha)	14.7	14.4	7.9	13.1	13.6	12.9	14.4	11.3	15.3	13.5	16.0
Moisture (%)	33.0	24.5	37.0	22.7	21.0	21.8	25.3	30.1	29.2	24.7	22.6
Lodging (%)	5	10	2	0	0	0	2	1	0	4	12
P3901 Yield (% of best hybrid)	86	92	98	100	100	100	92	90	95	82	91
Most popular hybrd in the Manwatu	XL45a	XL45a	P3709	P3901	P3901 P3709	P3901 P3709	P3901 P3709	P3901 P3709	P3901 P3709	P3901 P3709	P3709

[1] P = Pioneer brand hybrid. PAC = Pacific seeds hybrid. PX = Northrup-King hybrid XL = DeKalb Hybrid

[2] Cool growing season in the Manawatu region.

Table 4. Trends in yield (t/ha) from 1981 to 1989 for hybrids at several northern North Island sites and for P3901 at DSIR trials in the Manawatu.

		Year								
Hybrid	Site[1]	1981	1982[2]	1983	1984	1985	1986	1987	1988	1989
P3901	N	13.2	10.7	11.4	12.2	9.7	10.9	10.7	12.7	11.2
	M	13.3	7.7	13.1	13.6	12.9	13.0	10.2	14.5	11.1
P3709	N	12.9	10.4	10.7	12.2	9.2	11.1	10.3	14.2	11.9
P3591	N	11.9	10.6	9.7	12.6	10.5	11.3	10.6	13.4	11.6
P3551	N			12.6	13.5	14.1	11.6	11.7	14.9	13.6

[1] N = Mean of several Northern North Island sites (Pioneer). M = DSIR trials in the Manawatu.
[2] Cool season in Manawatu

It is often claimed by farmers that Hybrids 'run out', this term has no scientific basis but was described as the decline in desirable properties such as yield and disease resistance. However, the results of field trials at several sites in the North Island show that apart from normal seasonal variation, there is no evidence that a systematic reduction in grain yield occurred for any of these four hybrids at any of the sites between 1981 and 1989 (Table 4.). Therefore, replacement of one hybrid by another occurs when better hybrids are released, not when the performance of existing hybrids declines.

Conclusion

We have traced the history of the maize crop in New Zealand over the past 90 years. The greatest increase in grain yield during this period occurred between 1960 and 1980. We suggest that this was due to the introduction of improved crop management practices which allowed the realization of the production potential of hybrids which had been introduced earlier. Comparison of best farm yields and yields from experimental plots suggests that, New Zealand maize yields per unit area are considerably below the production potential of the crop.

There was no evidence that the yield of popular hybrid varieties has systematically decreased over the period they have been grown commercially. However, there was considerable variation in yield from season to season due to climatic variation.

Genetically based improvements in the yield of maize worldwide have been estimated to average between .03 and 0.1 t/ha/yr (Hallauer *et al.,* 1988) or about 1% per year over the 50 years to 1980. No reductions in this rate of improvement were evident. Over the past decade, the production potential of hybrids available in New Zealand and the national average grain production per unit area, have increased at about the same rate, suggesting that genetically based improvements are the primary contributors to improvements in crop productivity. However, some of the genetic potential of hybrids is still to be tapped by improving management of the crop.

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