Paper 9
BARLEY BREEDING IN NEW ZEALAND

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INTRODUCTION

Barley introduction and improvement have been going on in New Zealand since the advent of Captain Cook, but apart from a short, fruitful period after the Second World War, breeding in the accepted sense did not commence until 1960. At the time the maltsters were looking for a replacement for Kenia, which had first been introduced in 1937 by R.A. Calder, so the Crop Research Division of DSIR commenced a programme of crossing and selection, and stepped up their importation of overseas-bred lines. Carlsberg II had been imported as a high-yielding and malting variety but had performed poorly in the brew-house.

By 1965 the breeding programme had produced two lines, Pukeko and Weka, that had yields equal to Carlsberg II. These lines would certainly have been released, but in that year Zephyr was introduced from Holland and filled for the time being the maltsters' needs. Having pressed for a state breeding programme, and then underwritten its early operation, the maltsters were reluctant to let their investment drop, so they have continued to support the state programmes both financially and technically.

PERIOD OF CHANGE

By 1970 Zephyr had proved its worth, and was making its presence felt on the commercial scene. However, the stage was being set for the ferment of the 1970's. In North America the first transfers of breeding nurseries from one location to another, to obtain two generations per year, had started, and the idea was being viewed with interest by European breeders who had the notion that New Zealand would be an ideal off-season location for them. DSIR was in a good position to respond to their interest, for with the establishment of substations at Palmerston North in 1966, and Gore in 1972, Crop Research division could offer a range of growing conditions to suit many North European breeders. That it now offers facilities to breeders from Norway and Iceland in the north, to Southern France and the Mediterranean in the south, reflects this.

The next step, introduction of plant variety rights, saw many overseas breeding organisations gain confidence in the private side of the seed industry, and many joint ventures were established to grow nurseries and seed multiplications. The first result of this was a flush of new cultivars coming forward for testing, and the honour of being the first barley cultivar with plant variety rights lies with Hassan, introduced and marketed privately. Crop Research Division followed with three new locally-bred cultivars, Mata, Manapou, and Kaniere, the last of which is of feed quality only. This is a reflection of the increasing popularity of barley growing outside Canterbury and of the tremendous increases in production (of the order of 250%) necessitated by the change of the pork industry from milk-based to grain-based feeding. It is clear from the pedigrees of these three cultivars and their breeding histories that they were entering what may be thought of as a relatively unexploited environment, genetically speaking (Fig. 1). A total of nine land races have contributed to the development of these three cultivars, and four of these — Archer, Spratt, Gotland, and Moravia — are common to all three pedigrees. Of the remaining land races two are restricted to Kaniere, and Lower Bavaria may be assumed to be similar to Moravia. Similarly, Scania, which is contained only in the pedigree of Mata, will be of the same type as Gotland. So the only real source of variation between any of the Crop Research Division cultivars is the presence of the Saarland land race in the background of Kaniere. Further reference will be made to this situation later. The technique used to breed these cultivars is appropriate to a situation where there is considerable likelihood of making rapid improvements in desired characteristics. These varieties are all the result of compound crosses, made with the object of incorporating as much variation as possible into a segregating population in the knowledge that it must lead to substantial improvements over the less well adapted parent cultivars. That this was the case is shown by a comparison of trial results of the highest-yielding cultivars available in 1970 and 1980, Zephyr and Gwylan (Table 1).

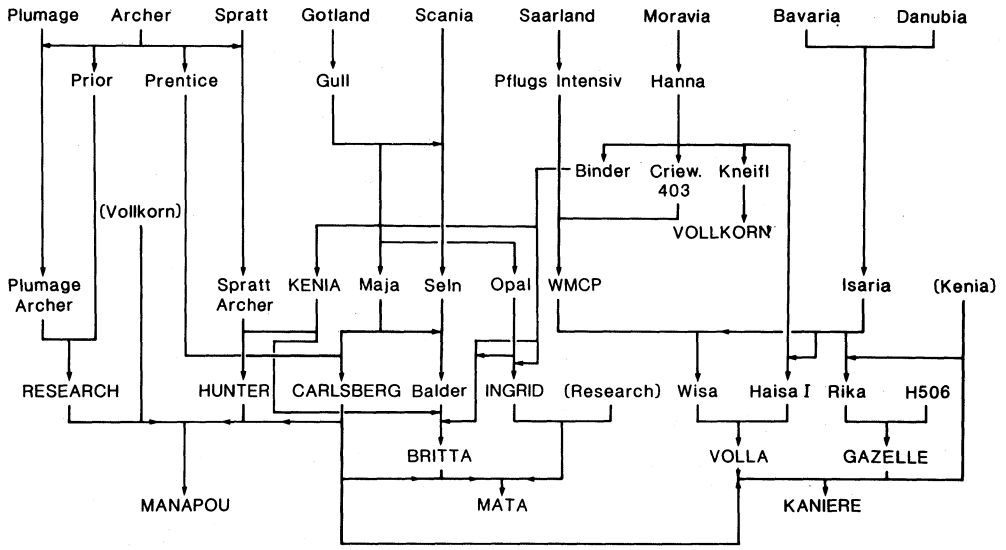

Figure 1: Pedigree chart for barley cultivars bred in New Zealand.

TABLE 1: Yield improvement in spring barley trials in North Canterbury.

Cultivar	1975 (dry spring)	1980 (wet spring)
Zephyr	86	100 (3.6 t/ha)
Mata	97	109
Manapou	102	103
Gwylan	—	125

Zephyr, the leading variety in 1970, was outyielded by 25% in 1980, indicating that breeding had made above-average advances in the decade.

Gwylan, one of the leading cultivars in trials in recent seasons, is the first fruit of the joint breeding programmes conducted by DSIR with overseas breeders. Its performance in trials when returned to the breeder in Wales was disappointing, so it would have been dropped if it had not yielded well at Lincoln. The easily made gains in yield of the past decade led to a large number of cultivars being released and marketed in New Zealand. Table 2 shows the share of the area occupied by each, as reflected by the returns made under the seed certification scheme. The quality of the majority of these cultivars is inadequate to meet the demands of the brewing industry, and consequently there has been a change in emphasis towards the production of cultivars with improved quality at the current yield levels. The aim is a Gwylan/Goldmarker that reliably provides extract percentages greater than 80.

INNOVATIONS

Because gains were made relatively easily, New Zealand breeders were slow to take advantage of the reciprocal opportunities offered by their agreements with overseas breeders. However, the breeders grew pilot nurseries in Copenhagen in 1976, and in 1978 Crop Research Division commenced a programme of nurseries in Copenhagen for the purpose of eliminating material from the local programme with unacceptable levels of straw strength or disease resistance. Several lines were returned for trial on the basis of their satisfactory appearance in Denmark. This was surprisingly successful, since each year thereafter one or more such lines have reached advanced trials here. This nursery is now well established and is being used to provide selections for further trials in various parts of Europe. More recently, the introduction of the doubled haploid technique (Jensen, 1975) as the object of a joint breeding programme between the DSIR and the Canterbury (NZ) Malting Company gives cause for optimism that the rate of progress in achieving the aims of higher yield with satisfactory malting quality will be maintained.

PROSPECTS

It is as well to pause and evaluate the position of barley and barley improvement at present, and reflect on possibilities for the future. The breeder, with his long-term view of the subject, has a unique standpoint. Barley seems still to have substantial prospects of expansion within New Zealand, primarily as an exportable commodity, either raw

or processed. Markets for our barley products will be limited while the cultivars we grow are unknown internationally, so there are two choices open to us. Either we grow cultivars that are bred elsewhere, and are saleable by virtue of their familiarity to European maltsters and brewers, or we produce cultivars locally that are acceptable internationally. The second option entails marketing cultivars as entities in international markets, with the additional return of royalties. Crop Research Division, at least, has settled for this course.

TABLE 2: Trends in percentage of certification areas for cultivars entered 1979/80, 80/81, 81/82.

Cultivar	1979-80 %	1980-81 %	1981-82 %
Ark Royal	5.0	3.0	4.2
Carlsberg	0.1	0.0	0.0
Georgie	7.0	13.3	15.6
Goldmarker	0.4	9.5	13.8
Gwylan	0.0	0.0	6.3
Hassan	12.4	12.4	13.2
Julia	1.9	0.6	0.5
Kaniere	18.4	12.1	10.0
Magnum	5.1	8.0	8.0
Makareta	0.0	0.0	0.5
Manapou[1]	1.7	2.0	3.0
Mata[1]	8.5	18.4	11.5
Pirouette	0.5	0.0	0.1
Universe	1.9	0.9	0.6
Zephyr[1]	36.9	19.7	12.2

[1] Acceptable for malting.

What advantages do we have to give us an edge in this highly competitive market? Is it reasonable to expect that New Zealand-bred barleys can compete internationally? The fact that overseas breeders do some of their selection here, as opposed to straight multiplication or pure seed production, supports the inference that the New Zealand environment has something to offer in a programme designed to produce cultivars for our target markets. Comparison of locally bred lines with lines bred elsewhere indicated seed quality was the area where DSIR-bred lines were most valuable. The majority of new cultivars released in Europe in the last five to ten years have been of the short-strawed erectoid type which tend to have small grain. Under any sort of stress this plant type throws high screenings, resulting in a sample unacceptable for malting, although suitable for feeding to animals. Breeding programmes to incorporate high grain weight in the erectoid require the rigours of the Canterbury climate for adequate selection pressure to be applied. Other aspects of seed quality that are under pressure here include beta-glucan content and protein content. In malting barley both these quantities should be low, and in Canterbury the agricultural practices followed cause the plant to have large amounts of nitrogen available under conditions of moisture stress, which will cause the levels of both protein and beta-glucan to rise if the plant is able to respond to the supply.

The incidence of disease in New Zealand also differs markedly from that found in Europe. Mildew and stripe rust occur at lower levels here, being quite unimportant compared to barley rust, scald, net blotch, and barley yellow dwarf virus. Consequently, selection against these diseases can take place in the field without the problem of accounting for the effects of controlling mildew or stripe rust.

The selection in the Canterbury environment over the past twenty years has failed to provide the gains in straw strength that might have been expected. Our cultivars are relatively resistant to straw-break, neck-break, and shattering, but not to lodging. It is obvious, from experience gained even in other parts of New Zealand, that the demands on straw strength imposed by the high winds, high temperatures and low humidity of the Canterbury summer are different from those found elsewhere. Several inferences can be drawn. Firstly, yields are generally lower in Canterbury than elsewhere in the country, so that the straw is not expected to hold up so large a head. Secondly, episodes where heavy rain and high winds combine to flatten crops are infrequent at the site where breeding is carried out. Those episodes that do occur involve strong southerly winds, which are relatively infrequent at the time the crop is sensitive. Thirdly, the type of root architecture likely to be favoured by the soil conditions prevailing in Canterbury gives less support to the stems above the crown. Low soil moisture and low levels of applied fertiliser cause the elaboration of primary roots, which grow downwards at the expense of the secondary root system, which tends to remain in the upper part of the soil profile. Finally, generally favourable harvesting conditions have meant that breeding material has seldom had to stand in the field past harvest ripeness. Having identified the likely causes of the weakness of locally-bred lines in other environments, the problems are to prove that these are indeed the causes of straw weakness, and to eliminate it. The first problem requires extra research, the second extra reliance on selection in environments where different types of lodging are a problem.

THE FUTURE

It is important to stress that the circumstances of the last ten years will not occur again. The New Zealand agricultural system now has cultivars better adapted than those available in 1970, so it will no longer be possible simply to import overseas cultivars and expect them to provide increases in yield and quality as has been done until now. Consequently the number of cultivars on the market will decline, because new ones will require much greater breeding effort and the market is too small to support the present number of cultivars if all were locally-bred. Logically, the development of joint breeding programmes is the next step. Already the DSIR has instituted one of these

in barley breeding, with the specific objective of improving malting quality. Other problems remain to be overcome, and it is probably through a combination of state and private resources that this will be achieved (Coles, 1980). As mentioned above, the spectrum of locally bred cultivars, and indeed of all the cultivars in use in New Zealand, is based on a very narrow pool of land races. It is essential to expand this base so that the chances of significant improvement in yield, quality, disease resistance and reliability of the crop are increased. The state breeding organisation is the logical place to attempt this expansion, which may then be followed by a joint exploitation of the fruits of that expansion by commercially oriented breeding programmes utilising private sector expertise. Particular programmes might include searches for increases in dry matter production, for better root architecture, for improved generalised disease resistance, for improved grain growth potential, and for better straw characteristics. In the long term, rewards for success will be enormous, but the initial investment must be made now. In the meantime, the expansion of our horizons is essential if barley breeding is to remain viable in New Zealand.

REFERENCES

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DISCUSSION

Q: Why are overseas breeders using the Canterbury environment for selection as opposed to multiplications?

Coles: Our advantage lies in the fact that our environment puts pressure on seed quality. The erectoid type barleys, which have been a major breakthrough in Europe in the last 10 years, have a small absolute seed size, and produce high screenings with a consequent reduction in quality. We get pressure late in the season, but are still able to select good seed size. Environmental pressure is also responsible for producing beta-glucan in the plants, which we try to minimise in our breeding programmes. I think also, with high fertility levels for sowing and relatively low inputs, we have to expect high nitrogen in our barley.

McFadden: Are quantity and quality mutually exclusive?

Coles: No. High yields imply the dilution of nitrogen content, but this is desirable for malting barley.

Wynn-Williams: Why do we not grow six-row barleys?

Coles: Because they don't have the yield, the straw quality is poorer, and they have high screenings.

Malcolm: In places like Canada, six-row barleys are relatively higher-yielding than two-row, and malting and brewing industries put up with inferior quality because of the economic factor.