Paper 4

POTATO BREEDING IN NEW ZEALAND

R.A. Genet and J.A.D. Anderson
Crop Research Division, DSIR,
Lincoln and Pukekohe

INTRODUCTION

Potatoes were introduced to New Zealand in 1769 by de Serville and became an important food source and trade item even before organised European settlement (Clarke, 1949). Early introductions were of diverse origins; often *andigena* types, and some still survive (Genet, 1984). Subsequently, a large number of British and American cultivars were grown in New Zealand. The first major breakthrough in potato breeding (or more accurately plant selection) in New Zealand occurred in 1910, with the selection of Aucklander Short Top from a crop of Suttons Supreme by A.J. Rich and M. Laws of Kaiapoi (Claridge, 1972). Although of minor importance now, more crops of Aucklander Short Top have been grown in New Zealand than any other cultivar.

Subsequently, New Zealand breeders attempted to produce new cultivars by controlled pollinations. Southern Cross, Constellation and Glen Ilam were produced but only filled minor roles. The potato breeding programme conducted by R.G. Robinson of Christchurch produced Ilam Hardy from a cross between Arran Pilot and Katahdin. It was released in 1951 and is still a major New Zealand cultivar. The main objectives of these early breeding programmes were tuber shape and yield. Little attention was paid to disease resistance.

Potato breeding began at the Agronomy Division of DSIR, (later named Crop Research Division) in 1934, the 1939-45 war severely curtailed this effort. Since the war there has been a continuous potato programme.

Early objectives of this programme included the improved shape and yield of previous programmes, as well as disease resistance, particularly resistance to late blight (*Phytophtora infestans*) and virus Y, and adaptability to the variable New Zealand climate.

The first releases from Crop Research Division (CRD) were Tahi and Rua in 1962 (Driver, 1962). Both were late maturing, high yielding cultivars. Rua has subsequently risen to nearly 40% of the New Zealand crop.

During the 1960's, the rapid increase in potato processing led to a demand for specialised processing cultivars, which would store better, and had low reducing sugar build up and high dry matter content. With the release of Wha, Rima, Ono, Whitu and Waru, during the 1960's and early 70's, it was hoped to fill these requirements. However, these cultivars have met with only limited success although all except Ono have occupied specialist niches.

Toru, released in 1972 established a small niche as a second early cultivar, but susceptibility to bacterial soft rot limited its success.

Iwa, an improved table potato, was released in 1976 and early indications are that it will be a success. Tekau was released in 1982 for both table and processing use and line 1015-47 is being considered as a replacement cultivar for second early and maincrop Ilam Hardy.

The potato breeding programme has gradually built up a background of disease resistant material which is continually being improved. Resistance to late blight and viruses X and Y are well established. With the discovery of potato cyst nematode (PCN) in Pukekohe in 1972, and subsequently elsewhere in New Zealand, nematode resistance became a breeding objective. As resistant parental material was not available in the breeding programme at that time several importations were made, including true seed with PCN resistance. Two lines from this seed, Sovereign and V170-1, were selected as potential cultivars but virus susceptibility and poor agronomic characteristics prevented their release. New Zealand bred PCN resistant lines are now at an advanced stage.

At present, CRD is the only potato breeder in New Zealand. Two separate but co-operative programmes operate at Lincoln and Pukekohe.

Crossing is conducted and seedlings are planted in the field at Pukekohe, and in the glasshouse at Lincoln. (Genet and Palmer, 1981). Selections from the seedlings of both programmes are maintained in a group 1 seed area at Waddington (in Canterbury). At Pukekohe, three tubers are retained and multiplied and further selected over the next two years, before fresh stocks are sent from material multiplied at Waddington.

Advanced lines from both programmes are trialled at a number of sites throughout New Zealand, both on research stations and on growers properties.

OBJECTIVES

Over the years, the number of breeding objectives has increased. No longer is higher yield alone sufficient reason to release a new cultivar. A large number of factors are considered (see Table 1).

Table 1. Major characters considered in New Zealand potato breeding.

Plant	Tuber	Pests and diseases	Quality
Total yield	Number size	Late blight	Dry matter
Marketable yield	Shape	Gangrene	Steaming
Stolon length	Eye depth	Dry rot	Crisping
Adaptability Maturity	Internal disorders	Virus X & Y Leaf roll virus	Damage susceptibility
	Growth cracks Secondary growth	Bacterial soft rot Potato cyst nematode	Glycoalkaloids

BREEDING MATERIAL

The first step in breeding a new cultivar is the choice of parents. Over the years, the range of material from which to choose has increased. Since potato breeding commenced at Lincoln, extensive use has been made of disease resistant lines from many countries, especially Great Britain, America and Australia, and more recently from Peru, Mexico and the Netherlands. Special mention should be made of some of this material:

- 119 series from CSIRO Australia with immunity to virus X and Y. These lines have been used extensively and are present in the pedigree of all cultivars released from CRD since 1972.
- Blight resistant lines from the Scottish Plant Breeding Station (now Scottish Crop Research Institute). These lines have been used extensively until recently to convey field resistance to late blight.
- B series from the U.S. Department of Agriculture. A wide range of important characters have been made available from this source between 1950 and 1970.
- Potato cyst nematode resistant lines from Cambridge, England, particularly D42/8 against *Globodera pallida,* and other commercial cultivars resistant to *G. rostochiensis.*
- International Potato Centre (Peru) material with resistance to leaf roll virus, bacterial wilt, frost, potato cyst nematode and late blight has been introduced recently.
- United States Potato Introduction Project (Wisconsin) material with resistance to bacterial wilt and insect attack, and some other tuber bearing *Solanum* spp.
- Breeding material with combined high levels of resistance to late blight and virus Y from Mexico.
- Lines resistant to potato cyst nematode from the Netherlands.
- Neo-tuberosum seed from the Scottish Plant Breeding Institute has made an important contribution to the widening of the gene pool. Also some recently acquired advanced cyst nematode resistant lines should be useful.

SPECIFIC BREEDING AIMS

Potato cyst nematode (PCN) resistance

This programme was started after PCN was found in New Zealand in 1972. Initial progress was slow because there was no resistanct material in New Zealand. Over the last 10 years, a range of resistant material has been imported.

Resistance to New Zealand pathotypes of *Globodera rostochiensis* is controlled by a single dominant gene (H_1) which is relatively easily transferred during breeding. A number of cultivars have been released overseas, some have been tried here, Maris Anchor having been accepted commercially.

Resistance to *Globodera pallida* is more complex, and is controlled by a number of genes. In New Zealand, two pathotypes of *G. pallida* (Pa2 and Pa3) have been recorded and breeding material has been obtained with resistance to both. So far, only a few cultivars resistant to *G. pallida* have been released worldwide and none have yet become very significant.

The adequacy of the levels of resistance to *G. pallida* in the CRD breeding material is shown by the results of a microplot field trial at Pukekohe against the Pa2 pathotype population — each cultivar was planted in the same plots over three years and the mean nematode populations after each year measured (see Table 2).

Table 2. Effect of different potato lines on *G. pallida* survival.

	G. pallida eggs and larvae/g soil			
	Initial	First year	Second year	Third year
Ilam Hardy	25	66 *a**	94 *a*	151 *a*
Wha	24	26 *b*	28 *b*	74 *b*
4696A(2)	22	18 *b*	19 *b*	27 *c*
Sovereign	23	7.2 *c*	1.9 *c*	1.4 *c*
D40/6	25	8.1 *c*	1.1 *d*	0.2 *e*
V390	25	6.3 *c*	0.4 *e*	0.06 *f*

*Letters apply to significant differences at the 5% level.

With material currently under trial at Pukekohe there are a number of lines which have shown a PCN resistance level equal to or better than Sovereign in pot tests, and in initial trials have performed at least as well as Ilam Hardy and Rua for yield, agronomic performance and quality. A *G. pallida* resistant variety will be released from this material.

The most widely used parent material in the programme for resistance to *G. pallida* has been obtained from the Plant Breeding Institute (PBI), Cambridge, U.K. and has PCN resistance derived from the *Solanum tuberosum* ssp. *andigena* clone CPC 2802 (Thomson, 1980). This material, including the PBI line D42/8, has given a good overall combination of nematode resistance and agronomic performance when crossed with CRD breeding lines. Other PBI material has been used which has resistance from CPC 2775, this includes the V170 series from which Sovereign was selected. *G. pallida* resistant material from the Scottish Plant Breeding Station, the International Potato Centre (CIP), and the Netherlands has also been used in the CRD programme, but to a lesser extent. It is hoped that further *G. pallida* resistant material can be obtained from these and other sources. Some of the *G. pallida* resistant material used also has the gene H_1 (for resistance to *G. rostochiensis*), and ultimately a high proportion of selections will carry resistance to both species of PCN.

At present over half CRD's potato breeding programme has special emphasis on PCN resistance.

Processing cultivars

At present, the main processing cultivar in New Zealand is Ilam Hardy. However, it has a number of defects, including deep eyes, tendency towards rough shapes, short storage life and low dry matter content. The processing industry requires a potato with smooth shape and high dry matter content, and which is capable of being stored for up to 8 months.

Russet Burbank is used extensively overseas for processing, but under New Zealand's changeable climate, growth cracks and second growth are common.

To date, the crossing programme for processing types has involved CRD processing cultivars like Wha, Ono, Whitu, Rima and Tekau, and breeding lines with good adaptability and freedom from physiological disorders. However, a number of American processing cultivars, e.g. -Kennebec, Shepody, Belrus and Dakchip have recently been imported and used in the crossing programme.

Early maturing cultivars

At present, the only early cultivar of any importance in New Zealand is Ilam Hardy. While this cultivar, with a few of less importance, adequately fills the first early slot, the early main crop slot is inadequately covered. Previous CRD releases, except Toru, have been late maturing. There is now a programme aimed specifically at breeding for earlier maturing cultivars.

Considerable use has been made of Arran Banner, Epicure and other more recent British cultivars. However, it has been difficult to find lines which consistently outyield Ilam Hardy. A recent survey of early maturing breeding lines failed to identify any parents which consistently produce good early maturing lines. However, a number of lines are now showing promise, and one (1015-47) is being considered for release.

Widening the potato gene pool

Most potato cultivars in the world have been bred from within *Solanum tuberosum* subspecies *tuberosum*. It has been estimated that in the selection of the potato cultivars grown in most countries, no more than 5% of the total genetic variability within the tuber bearing *Solanums* has been utilized. (Mendoza, 1979). Advances in potato breeding will be limited if breeding is restricted to the subspecies *tuberosum*. Introductions from other species and the subspecies *andigena* will provide better yield, pest and disease resistance, and other characters.

Unfortunately, the use of other species can be difficult and very time consuming (Sneep *et al.,* 1979). Extensive backcrossing is necessary to remove undesirable genes also transferred from the wild species, and many tuberise only in short days which makes them very late maturing in temperate regions.

One species that has been imported into New Zealand for special consideration is *S. berthaultii.* The sticky lobed trichomes of this species were reputed to trap aphids and thus confer some resistance to these pests. Recent information is that *S. berthaultii* produces an aphid alarm pheromone *((E) β farnesene)* which repells aphids from the leaves (Gibson and Pickett, 1983). A few test crosses are planned to see whether this characteristic can be transferred to the CRD breeding material.

Other species maintained at CRD include *S. phureja, S. hjertingii, S. acaule, S. stenotomum,* and *S. pinnatisectum*. However, CRD's potato programmes are too small to effectively utilize wild potato species and better, faster incorporation can be achieved by importing adapted or semi-adapted material. Increasingly, organisations like CIP, have available a wide range of material, some with specific attributes adapted to New Zealand's long-day, temperate conditions (Bryan, 1981). Utilization of this material is within the scope of CRD's programmes.

Neo-tuberosum material, originally developed by Simmonds in Britain from a sample of mainly Bolvian and South Peruvian *andigena* which was subjected to successive generations of mass selection (Glendinning, 1975), has resulted in a diverse potato gene pool adapted to temperate latitudes. This material contains the valuable genes from *andigena,* with a much lower frequency of undesirable characters. A sample of neo-tuberosum material was first evaluated in New Zealand, in 1978/79, when true potato seed obtained from the Scottish Plant Breeding Station was grown. Clones selected from this material have been used as parents in both the Lincoln and Pukekohe breeding programmes and the first progeny were grown in replicated trials in 1982/83. This neo-tuberosum material appears to have real potential in broadening the genetic base of the programmes and introducing higher yield. It is planned to obtain further neo-tuberosum material from CIP, North America and Europe in the near future.

Also aimed at broadening the gene pool, is a programme to cross surviving Maori cultivars, from outside the normal *S. tuberosum* gene pool, with other parents in the breeding programme.

TESTING AND EVALUATION

Early generation rejections are mainly concerned with long stolons, virus infection, rough shape or deep eyes. After the third generation, there are usually sufficient tubers to allow a replicated trial, from which yield data, dry matter content, steaming and crisping suitability, disease and pests incidence and damage susceptibility are evaluated. A brief outline of these tests follows.

Viruses

Virus X and virus Y. Resistance to these viruses has been a long term priority of the CRD programme and most CRD cultivars have resistance to both. At Lincoln, seedlings are usually spray inoculated at the seedling stage, and those that are susceptible discarded.

Lines being considered for release are seriologcally tested for resistance to X and Y by Plant Diseases Division of DSIR at Lincoln. No cultivar is released from CRD's programme without resistance to X and Y unless it appears otherwise outstanding.

Leafroll virus. Resistance to leafroll virus was seen as a major priority when the Pukekohe breeding programme started in 1972, but is now a much lower priority. Using the present breeding methods, however, it is unlikely that any advanced clone would be highly susceptible. A level of resistance that allows seed to be replanted once from crops grown in high risk areas is useful. CRD varieties, such as Wha and possibly Iwa, have this level of resistance.

Fungal diseases

Late Blight (*Phytophthora infestans*). Resistance to this disease was a breeding priority in the early stages of the CRD programme and many cultivars have a reasonable level of field resistance. Late blight is an expensive disease to control and at least a moderate level of field resistance should remain as a breeding priority. In recent years, little data has been collected on the resistance of breeding lines to late blight. A cultivar resistance trial at Pukekohe was planted in 1983 and will be continued on a regular basis.

Rhizoctonia *Thanatephorus cucumeris* (syn *Rhizoctonia solani*). Rhizoctonia is a predominant factor in poor emergence of Rua which is a highly susceptible cultivar. It is therefore a major problem in New Zealand. Most lines likely to be released would be less susceptible than Rua, but consideration should possibly be given to developing a screening method for resistance.

Gangrene (*Phoma* spp.). This is a major disease of potatoes and is a priority of many potatoes breeding programmes worldwide. Effective screening programmes have been developed (Jellis, 1978). Routine screening for gangrene is conducted at Lincoln for both the CRD programmes.

Dry Rot (*Fusarium* spp.). A similar screening programme to that for gangrene is being conducted.

Bacterial soft rots (*Erwinia* spp.)

These can be a major problem, especially in warm humid storage (e.g. plastic bags). Until recently, testing was fairly subjective, based on the amount of rotting occurring during a short period of storage after trials are harvested at Pukekohe. Most cultivars currently grown in New Zealand are fairly susceptible and there is a real need for more resistance. A screening programme has now been developed, in association with Plant Diseases Division of DSIR in Auckland, using a technique similar to that developed by Bourne *et al.* (1981).

Tuber moth (*Phthorimaea operculella*)

There are differences between cultivars in their susceptibility to tuber moth, due to both depth of tuber setting and attractiveness to the moth. This is an important pest and comparative assessments in susceptibility are obtained in both Pukekohe and Lincoln maincrop trials.

Yield

Although high total yield is desirable, a high saleable percentage is of greater importance.

Quality

This aspect continues to command increased importance with a number of different tests performed. Samples from all advanced trials are sent to Lincoln for quality evaluation.

Dry matter — specific gravity tests correlate well with dry matter content, which is an important characteristic for the processing industry.

Steaming — tests are conducted to rate steaming quality for taste, sloughing, greying, texture, stem-end blackening and flesh colour.

Crisping — crisps are made and their colour, which correlates with reducing sugar content, measured.

Black spot bruising — a test to rate susceptibility to black spot has been developed and is performed on all advanced lines.

Physiological disorders — samples are cut longitudinally and examined for hollow heart, vascular ring discolouration and fleck or internal rust spot.

Glycoalkaloids — it is planned to test all lines for glycoalkaloid levels prior to release.

Potato cyst nematode

Progeny from resistant parents are screened for resistance in pots in a glasshouse at Pukekohe and in a controlled temperature room at Lincoln. Immature female nematodes can be counted on the roots. *Globodera* *rostochiensis* resistors with the gene H_1 show no cysts, while *G. pallida* resistance is judged as a percentage of the number of cysts produced on a susceptible host, usually Ilam Hardy.

NEW METHODS

A number of new techniques and breeding options are being developed overseas, such as breeding at the diploid level, (Sneep *et al.,* 1979), using protoplasts, (Shepherd *et al.,* 1980) and using true potato seed (TPS). Apart from some co-operation with Dr A.S. Bedi on TPS, CRD has not had the resources available to spend time on these new techniques, however developments are being followed closely.

CONCLUSION

New Zealand has been well served by its potato breeders. Today, over 94% of the crop is planted with New Zealand bred cultivars, (Cleverley, 1983). Compared with overseas programmes, CRD has had a comparatively successful programme, especially with the releases of Rua and Iwa. Even though the standards and requirements of potato cultivars today continue to rise, we are confident we have material to continue supplying better cultivars for New Zealand and hopefully for sale overseas.

REFERENCES

Bourne, W.F., McClamont, D.C., Wastie, D.L. 1981. Assessing potato tubers for susceptibility to bacterial soft rot. *Potato Research 24:* 409-416.

Bryan, J.E. 1981. *Pathogen Tested Potato Cultivars for Distribution.* International Potato Centre, Lima. 14 pp.

Claridge, J.H. 1972. Potatoes. In: *Arable Farm Crops of New Zealand.* DSIR and A.H. & A.W. Reed, Wellington: 229-296.

Clark, A.H. 1949. Potatoes. In: *The Invasion of New Zealand by People, Plants and Animals: the South Island.* Rutgers University Press, New Brunswick: 293-302.

Cleverly, D.A. 1983. *Seed Potato Certification in New Zealand.* Ministry of Agriculture and Fisheries. 32 pp.

Driver, C.M. 1960: Tahi and Rua — Two new potato varieties. *N.Z. Journal of Agriculture 101:* 218-220.

Genet, R. 1984. Old "Maori varieties". *DSIR Field Crop News 8:* 18-20.

Genet, R., Palmer, T.P. 1981. Potato Breeding — Crop Research Division. *N.Z. Potato Bulletin 83:* 10-11.

Gibson, R.W., Pickett, J.A. 1983. Wild potato repels aphids by release aphid alarm pheromone. *Nature 302:* 608-609.

Glendinning, D.R. 1975. Neotuberosum: new potato breeding material. *Potato Research 18:* 256-261.

Jellis, G.J. 1978. Determining the susceptibility of potato clones to gangrene (*Phoma exigua* var. *Soveata). Potato Research 21:* 135-143.

Mendoza, H.A. 1979. *Breeding Research at the International Potato Centre: Philosophy and Methodology for the Utilization of Available Genetic Resources.* International Potato Centre Lima. 23 pp.

Shephard, J.F., Bidney, D., Shahin, E. Potato protoplasts in crop improvement. *Science 208:* 17-24.

Sneep, J., Hendriksen, A.J.T., Holbeck, O. (Eds) 1979. *Plant Breeding Perspectives. D.J. van der Have 1879-1979.* Centre for Agricultural Publishing and Documentation, Wageningen. 435 pp.

Thomson, A.J. 1980. Potatoes 3: Breeding for temperate agriculture. *Span 23:* 70-72.