He Kōrero Kōrari

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Review of harakeke evaluation trial 1994 – 2002

Manaaki Whenua
Landcare Research

Contents

He Poroporaki

Emily Schuster

The passing of Emily Schuster in September 1997 was a huge loss for us all, with her many contributions to cultural life. It was through Emily's initiatives that the harakeke evaluation was conceived. She was its strongest supporter and we sorely missed her guidance and interest in the progress of the harakeke research programme.

Cath Brown

We were fortunate indeed to have the active support of Cath Brown, renowned Ngāi Tahu artist and weaver, throughout the course of the harakeke evaluation trial. Despite her illness, Cath retained a keen interest in the progress of research on weaving plants, and had a key role in planning the new weavers' research programme. Sadly, Cath passed away in August 2004.

Rangi Kiu

Rangi was a hugely talented artist who passed away in March 1998 at a tragically young age, but lives on in the stunning weaving and artwork he left behind. In his quiet, good-humoured, practical way, he supported this evaluation trial, and helped at the planting of the Otatara site.

Nō reira, haere, haere, haere atu rā.

Why did we set up an evaluation trial of weaving varieties of harakeke?

Anecdotal evidence suggests that the weaving qualities of harakeke change when the plants are grown in different places. For example, Kōhunga is favoured by Diggeress Te Kanawa in Te Kuiti for the thick, easily extracted muka (stripped fibre) that is so suitable for whenu (warp) in cloaks. However, Cath Brown, Taumutu, found that Kōhunga grown in Canterbury does not strip easily – the para (leaf matter) is

Consultative hui, June 1995. L to R, Shane Munn, Cath Brown, Diggeress Te Kanawa, Emily Schuster, Warwick Harris, Waana Davis, Margaret Bond, Te Aue Davis, Murray Parsons, Blanche Hohepa.

inclined to adhere – and is therefore not the best variety to use for muka in this region.

Warwick Harris had the idea of measuring environmental effects such as soil and climate on plant form, growth and the weaving properties of harakeke varieties. With the support of weavers Emily Schuster and Cath Brown, he applied for government funding to establish three trial sites in separate locations where clones (divisions from the same parent plant) of several different varieties would be planted and later measured and assessed for varietal differences in growth and weaving properties.

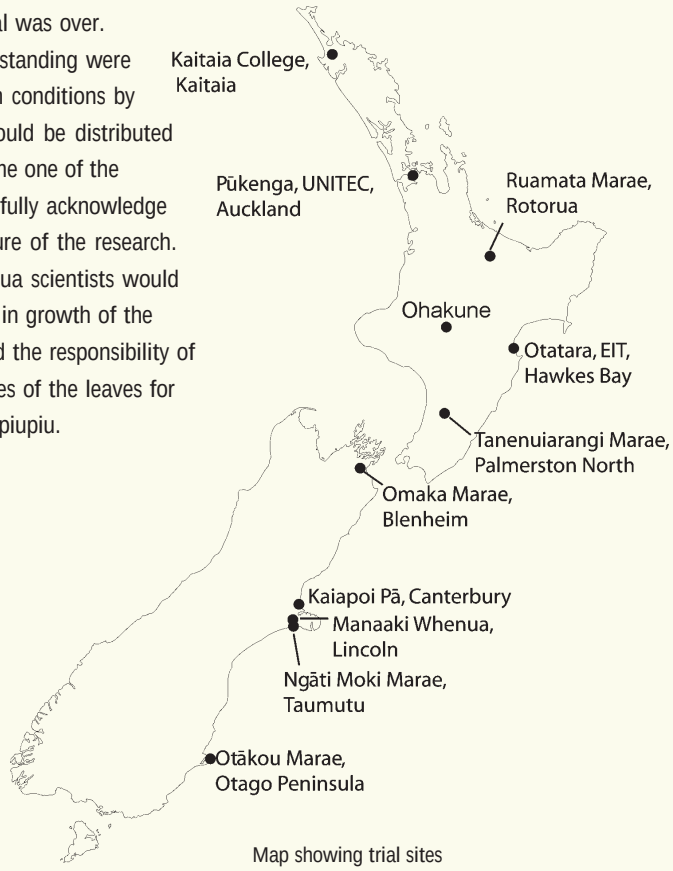
The idea was further fostered by the expansion of the Manaaki Whenua site at Lincoln. As part of an international hui on ethnobotany in 1988, 12 varieties from the Orchiston Collection were ceremonially planted close to the main buildings at Lincoln. The varieties represented a range of forms, uses and origins. In July 1994, the flaxes were dug up to make way for a new building, providing plenty of clonal material for use in the experiment.

The consultation process

The proposal for a harakeke evaluation trial was formally presented by Warwick to a Te Waipounamu weavers' hui at Taumutu in October 1994 and greeted favourably.

Also that year, Te Roopu Raranga Whatu o Aotearoa, the national association of Māori weavers , was formed. Key members visited Lincoln in June 1995 to further discuss the proposed trial. This was followed by another consultative hui at Ngāti Moki Marae, Taumutu, in August 1995.

Following these discussions, the list of experimental sites throughout Aotearoa was increased to ten. This was to ensure a wide community involvement and to provide a weaving resource for local communities once the trial was over. Memoranda of Understanding were drawn up to establish conditions by which information would be distributed (this newsletter became one of the mechanisms), and to fully acknowledge the collaborative nature of the research. While Manaaki Whenua scientists would measure the changes in growth of the varieties, weavers had the responsibility of evaluating the qualities of the leaves for raranga, whatu and piupiu.



Map showing trial sites

The trial layout

When we break a large harakeke bush into its constituent fans (or strictly speaking, ramets), each fan belongs to the same clone – i.e., it has the same genetic component as the parent plant. This is very useful as it means there is less need for replication than if plants raised from seed are being compared. Harakeke raised from seed is very variable in form.

Harakeke varieties used in the trial were:
Arawa, Paretaniwha, Ngaro, Ate, Tapamangu, Kōhunga, Tāpoto, Hūhiroa, Paoa, Parekoretawa, Oue, Māeneene.

Descriptions and uses can be found in *Harakeke. The Rene Orchiston Collection* S. Scheele and G. Walls (ed), 1994. Manaaki Whenua Press, Lincoln.

Nonetheless, there are some differences that we need to make provision for so that we can be sure our comparisons are valid across sites. For instance, some fans may be older or of different sizes when divided. Within each site, there may be differences in soil fertility, moisture, shade and shelter that will affect the growth and form of the plants.

To compensate for this problem, we grew three plants of each of the 12 varieties at every site. The varieties were evenly spaced 2.5 m apart in three blocks of 12 plants that were laid out to take account of likely differences in the site environment. The 12 varieties were planted randomly within each block, both within and between sites. This was to avoid the possibility of the performance of a particular variety being influenced by it always having the same neighbours.

Why do we plant fans of weaving varieties instead of sowing the seed?

In short, by planting fans we are planting clones, or genetically identical material, of the parent harakeke. Weavers harvested particular bushes of harakeke because the leaves had desirable characteristics for different purposes. They ensured desirable traits were maintained by growing divisions of the selected plant.

Plants reproduce in two ways, through flowering and the production of seed (sexual reproduction), or by vegetative reproduction (cloning) – where a living piece of the parent plant is separated off and planted.

Many plants grown by people are multiplied by cloning. Potatoes, for example, have specialised organs for vegetative cloning. These are the tubers in which potatoes store carbohydrate and other plant food to carry them through the cold winter months when their leaves are killed by frost. In spring, new plants are formed from the tubers that are genetically identical to the plant grown the summer before. If we buy a bag of potato seed-tubers of a named variety such as "*Rua*", we can be sure that the resulting crop of potatoes will consist of genetically identical tubers of the variety.

Potatoes also produce flowers that can produce seed by sexual reproduction. A potato plant breeder can produce a new variety of potato by introducing pollen from one variety of potato to the seed-forming part of the flower of another variety. Usually, several or many seeds will be formed by this process. If this seed is sown, the resulting plants will be all genetically different from each other and also from the mother (seed) and father (pollen) plants.

It's the same story with harakeke. If we want to retain exactly the same properties as the parent plant, then we separate off a ramet (fan) with root material attached, for planting elsewhere.

In producing seed, harakeke deliberately mixes up the characteristics of the parent plants. The flowers produce nectar that attracts birds like tūi, korimako (bell birds), and starlings. These birds spread (male) pollen from the flowers of different kōrari and different plants, which fertilise the female "eggs" within the flowers. The seeds that are created are genetically different from the parent plant and from each other.

So, although this is a healthy way for a plant to create offspring, we won't get the same weaving properties if we sow seed from a harakeke bush rather than dividing off a fan. The resulting seedlings will not have the same characteristics as the parent plant. They may grow to perform very well as a weaving variety – but we cannot be sure.

Seedlings also take much longer to grow to maturity. It will take 6 – 8 years before harakeke grown from seed is ready to harvest. If conditions are good, a plant of harvestable size can develop in 3 years from a fan.

Preparing the harakeke for the trial

The harakeke bushes were divided into separate fans in September 1994, a year before being planted at the trial sites. They were trimmed back to the central three leaves – the rito or growing shoot, and the matua, the protective leaves on each side of the rito. The fans were heeled in, watered, fertilised and weeded to help them grow new roots and leaves. When the time came to take the plants to the sites, the fans were trimmed again. Trimming the leaves reduces the loss of water from the plants. If extra fans had developed, these were divided off again to single fans.

Site plantings – Spring 1995

Warwick Harris and science technician Rowan Buxton carried out the huge task of planting the 10 trial sites. Below is Warwick's edited account of their initial journey, written in November 1995.

Lincoln, Canterbury
Planting date: 4 September 1995

We chose the Manaaki Whenua campus at Lincoln as the first site, to gain experience of how to best prepare the plants and set up the planting layout. The Lincoln planting is on a flat area of fertile soil. The weed matting here was laid in six continuous strips over the holes we had dug for the plants. We then cut through the matting over the holes and inserted the plants. This was awkward and so we decided that for the other sites we would first plant and then put squares of matting over the plants. Using weed matting, however, certainly helps the fans from being smothered by weeds.

The soil at Lincoln was moist at planting and a good rainfall came soon after.

Lincoln trial site.

Newly planted trial at Taumutu.

Erena McNeill explains the planting procedure to students, Kaiapoi Pā.

However, we have had a dry spell since and the plants have been watered once. They are all surviving and many are starting to grow, though most have some dieback of their leaves.

At all the sites, the plants were staked and tied to help them remain firm in the soil until they had regrown the roots needed to anchor them. Without this, strong winds blowing the matua leaves may have loosened the plants or, where the soil was very wet, tipped the plants over. However, tying the leaves to the stake can distort the emergence of the rito from the folds of the matua leaves. Once the plants began to grow new leaves, the ties were cut. The stakes, though, were left in place until the plants were growing strongly, usually a year after planting.

Taumutu, Canterbury
Planting date: 12 September 1995

Taumutu is about 30 km south of Lincoln close to Waihora (Lake Ellesmere). Here Cath Brown planted the first fan with a karakia. Cath also explained the arrangement of the fan with the bulge of the rito (growing shoot) placed facing east to receive the warmth of the rising sun, and the matua leaves on either side protecting the shoot from the heat of the midday sun and the cold of the southerly wind. This planting arrangement was followed at all the other sites.

The Taumutu planting is within the boundary of the ancient Orariki Pā and receives some shelter from old macrocarpa trees alongside the whare karakia and urupā. However, it is only about 200 m away from the shoreline, which is very exposed to southerly winds and storms. The soil is also fairly light with a high sand content. In droughty summers this will be one of the driest sites.

Jeremy Sheat and helpers have erected a strong fence around the planting. When I last visited Taumutu I took some kānuka brushwood and tied it to the fence to provide windshelter.

Kaiapoi Pā, Canterbury
Planting date: 21 September 1995

Kaiapoi Pā lies about 30 km north of Lincoln, and is a key cultural centre for Ngāi Tahu although it has not been lived in since it was sacked by Te Rauparaha in the 1830s. Approval to site the harakeke evaluation at the Pā was given by the

Shell and umu stone fragments excavated from a planting hole, Kaiapoi.

Kaiapoi Pā Trust chaired by Rakiihia Tau of Ngāi Tūāhuriri. The planting is in the old garden area, Te Māra a Tuhoro Kaka. Chris Jacomb, archaeologist at the Canterbury Museum, supervised the digging of the holes for planting, which revealed a great number of shells and umu stone fragments.

Preparatory work had been organised and supervised by Erena McNeill and the site was covered with newspaper, cardboard and bark mulch to control weed growth.

This is the only site without weed matting. Erena had arranged that staff and students of the Van Asch School for the Deaf join in the planting. Their enthusiastic participation, aided through sign language telling them of the significance of Kaiapoi Pā and of harakeke to Māori, was a joy to be a part of. In the week that I was planting in the North Island, a group of Christchurch Polytechnic students came and added border plants around the replicated planting of 12 varieties.

Students of the Van Asch School for the Deaf gathered for the planting at Kaiapoi Pā.

Otākou Marae, Otago Peninsula
Planting date: 27 October 1995

The site stands off Tamatea Road above the marae buildings and faces northward with a splendid view of the entrance of Otago Harbour. It is the most southern of the sites. Within the fenced area, a sheltered hollow protected by hedging was marked out for the planting by Rowan, Peter Heenan (a Manaaki Whenua colleague) and me. Doug Ditford (who represented the marae at the consultative hui, Taumutu, in 1995) and his mate took time away from finishing the fencing, and with Moana Wesley helped with the planting. Moana planted the last of the harakeke, and together, Moana and Doug concluded with a karakia.

Omaka Marae, Marlborough
Planting date: 8 October 1995

This is an urban marae close to Blenheim. Margaret Bond invited us to put a trial site there, at the weavers' hui, Taumutu, in October 1994.

The Omaka site stands on flat ground in an area just north of the entrance to the marae and wharenui. The soil was moist and easily dug when we planted. Judging from the growth of the harakeke that border the marae, the plants should grow well here once they get through the first of the typically dry Marlborough summers they will encounter. Near the planting is a building bearing the name Te Whare Pora. Margaret's mother, Kath Hemi, told me that Emily Schuster, [then] Convenor of Te Roopu Raranga Whatu o Aotearoa, had taken part in the opening of this house of weaving. One day, I hope, harakeke from the planting will be taken into this house and used to continue, sustain and advance the ancient practices of Te Whare Pora.

Moana Wesley, Doug Ditfort and Warwick Harris lay out weed matting, Otākou Marae.

Planting the harakeke at Omaka Marae.

Rangi Kiu and Warwick Harris at Otatara planting.

Eddie Kiriona, Blanche Hohepa Kiriona and Rowan Buxton at the planting, Ruamata marae.

Otatara, Eastern Institute of Technology, Hawke's Bay
Planting date: 9 October 1995

This site was organised by Jody Stent and Bana Paul, as trustees of the Otatara Rōpū Raranga Charitable Trust. Bana had attended the weavers hui at Taumutu in August.

The site at Otatara stands on the slope of a hill just below a picturesque group of old farmstead buildings that provide the studios and working areas for several artists. It is a well-sheltered site exposed mostly on its eastern side, with a view over the Heretaunga Plains. To prepare the site for planting we had to break up and dig deep into the compacted subsoil. Rangi Kiu worked hard with us so that when Jody returned from giving a course later in the afternoon the planting was completed. To my eyes the completed planting looked like a work of art compatible with its surroundings!

Rangi later took us into the whare pora to show a beautiful kete and harakeke cloak he had made. These were remarkable for their innovative design and fineness of the weaving.

Ruamata Marae, Rotorua
Planting date: 10 October 1995

Ruamata Marae stands near the shore of Lake Rotorua, close to Rotorua Airport. I first visited Ruamata Marae with Emily Schuster in March 1995, and with Hiko Hohepa we found a place for the planting on the land that surrounds the marae. We also met with and discussed the harakeke evaluation with weavers who were busily making whāriki for a wharenui in the Rotorua District. Here I met Blanche Hohepa, who attended the weavers' meeting at Lincoln in June. Hiko and Emily came to the weavers' hui at Taumutu in August.

The site is sheltered on a flat area running down to the shore of Lake Rotorua. The Ruamata Kura Kaupapa is uphill of the site, across a large area of mown grass. Working between rain showers and ducking under aircraft coming into the airport, we completed the planting with the help of Blanche and her husband Eddie Kiriona. The planting was into long grass and we had to clear away some blackberries. Although the soil was very wet when we planted, it is a free-draining volcanic soil in which the harakeke should grow well, provided they can compete with the lush growth of the grass.

Trial at Ruamata marae with Kura Kaupapa in background.

Students and staff at Pūkenga, UNITEC, join in the planting.

Emily Schuster and Hiko Hohepa selected the Ruamata site.

Pūkenga, UNITECH, Auckland
Planting date: 11 October 1995

Several strands led to the site at UNITECH. At one stage, the plan was to plant at Puhinui, south of Māngere, in association with Del Wihongi and the Pū Hao Rangi Māori Trust. The option of a site at UNITECH developed from meeting Kahu Te Kanawa at the Te Waipounamu Weavers Hui at Taumutu in October 1994. Kahu immediately identified the usefulness of the harakeke evaluation for her role as weaving teacher at Pūkenga. From this followed negotiations with Haare Williams and Haare Paniora for a site at UNITECH. This site was supported by Pū Hao Rangi and gained wider approval from Auckland iwi. Kahu's involvement is of great significance as a link to the key roles her mother, Diggeress Te Kanawa, and grandmother, Dame Rangimarie Hetet, have played in the revitalisation of Māori weaving.

Rowan and I marked the layout, and all was ready when staff and Kahu's students arrived for the planting at 2 o'clock in the afternoon. Kahu planted the first fan, and the emotion of the occasion was raised further for her when she found that the variety she had selected was the favourite of her grandmother Dame Rangimarie. Then everyone joined in the planting, arranging the weed matting around the plants, staking and tying them.

The planting follows the contours of a gully on the eastern-facing slope. Alongside the stream in the gully, harakeke, toetoe and other native species have been planted at Kahu's request to provide a source of materials for her teaching courses. The soil and sheltered position of the site and Auckland's warm moist climate should provide an excellent environment for the growth of the harakeke.

Kaitaia College, Kaitaia, Northland
Planting date: 12 October 1995

Lydia Smith suggested a school site for the experiment, and chose Kaitaia College because it draws in a wide group of people in the Far North, and because of the opportunity to bring harakeke into several aspects of the secondary school curriculum. This association was very timely as 1995 was the year that Kaitaia College started its bilingual unit. The involvement of Kaitaia College received the endorsement of Korou Marae, Ahipara. A site was selected for the planting that stands above the College's playing fields in an area sheltered by gumtrees.

When we arrived at Kaitaia College, we saw in the foyer an enlarged copy of the planting plan. The area was decorated with a display of beautiful woven articles brought together by Lydia Smith. These were articles that were to be included in the display prepared for the national weavers' hui to be held at Te Hāpua during Labour Weekend.

At the site, it was a very pleasant surprise to find that the planting layout had been marked out and the holes already dug to receive the plants. We were joined by a notable assembly of people and greeted by a superbly presented pōwhiri led by Pare

Saana Murray tells her harakeke to grow tall and strong.

Students planting harakeke, Kaitaia College.

Nathan and the students of the bilingual unit and a speech of welcome from Principal John Locke. It was a special pleasure to have the support of Saana Murray.

The first of the fans were planted by respected kuia, who gave their blessings and encouragement to the plants to grow strong and well. Then the tamariki of the Bilingual Unit joined in with great enthusiasm, adopting the plants as companions with whom they will grow up over their years at Kaitaia College. Very quickly all the fans were planted, protected by weed matting, and staked and tied. Even though the holes for planting had filled with water in what appears to be a heavy soil, the planting was completed in a very orderly and tidy way.

Maungarongo Te Marae, Ohakune
Planting date: 14 October 1995

My brother-in-law, Jack McLean, had suggested there was likely to be local interest in hosting a site here. Certainly, it represented an extreme environment for the harakeke. I made initial contact with the local marae through Colin Richards, a practitioner of rongoa who works with the Department of Conservation. Colin fostered the contact with Maungarongo Marae, and through Biddy Mareikura, Lisa Mareikura was able to attend the hui at Taumutu in August 1995. I met with the whânau Mareikura at the marae early in September.

An area within the marae compound was chosen, and it was agreed that some preparation of the area would be desirable before the planting took place. Unfortunately, the work couldn't be done before our arrival for the planting. It should, with care, be possible to do the clearing needed by working around the planting site. A fence would provide added security from cattle that may stray into the marae.

The day of the planting was cold and very windy. The Ohakune site provides a useful contrast as it is located at a higher altitude and further inland than the other sites and provides a wet and cold environment for the harakeke. The volcanic soil appears to be deep and adequately drained and should support the growth of the harakeke if they can stand the rigorous climate. In what were very unpleasant weather conditions we were helped by members of the Mareikura family, and had a welcome respite when the marae caretaker welcomed us into the whare mahana for warming tea and kai. It was then we found that all the sensible people in Ohakune were staying warm at home watching World Cup Rugby League on TV!

Maungarongo Marae, Ohakune – trial planting.

An extra site
Tanenuiarangi Inc., Palmerston North
Planting date: 24 April 1996

Early in 1996, Ruth Harris and Dianne Taumata of Tanenuiarangi Manawatu Inc. asked if it would be possible to have a planting at their location in Palmerston North. There were just enough plants of all the 12 varieties to establish one more full planting, and a site in the moist, mild climate of the Manawatu on fertile soil added to the range of conditions in which the harakeke were being grown.

Among those who took part in the planting were Ruth and Ivan Harris, Rev. Tunu Walker, Rangi Fitzgerald, Tamati Kaiwai, Inia Te Rangi, Kararaina Tait and Dianne Taumata, and from Manaaki Whenua, Rau Kirikiri and Garth Harmsworth.

At Tanenuiarangi the plants have been arranged along fences that surround the entrance to the building complex. As at other sites, the plants were arranged so that the rito faced the rising sun, were surrounded by weed matting and were staked and tied to hold them firm against the wind until their roots developed.

Measuring gear.

The progress of the trial 1995–1999

Warwick Harris and sometimes Sue Scheele visited the sites every 6 months between Spring 1995 and Spring 1999 to measure the growth of the harakeke, help in plant maintenance, and network with the weavers and groups involved. We have reproduced below some of the main comments and highlights of those visits.

Among observations recorded were: number of new leaves and estimated percentage of dieback on original leaves (autumn 1996 only); number of new fans developed since planting; length and width of two largest leaves; frost damage to rito; basal circumference of bush; signs of damage to leaves by insect pests and diseases. Soil samples were also taken from each site. A figure on page 28 shows the changes in basal circumference of harakeke at all sites over the period of the observation trial.

Lincoln

At Lincoln, Warwick was able to regularly follow the establishment and growth of the plants. This planting was used to develop the measurement techniques that were applied to all the sites on the 6-monthly visits in spring and autumn.

The first summer 1995/96 was very dry, and plant growth was restricted by both the shortage of water and the plants' poorly developed root systems. A higher percentage of the original rito and matua leaves suffered severe dieback compared with the northern sites. Winter frosts in 1996 severely damaged some plants, though others were not affected. At the spring 1996 measurement, 21 plants had more than one fan (average 2.4).

Over summer 1996/97, a *Paretaniwha* and a *Tapamangu* plant died and were replaced. The fans of these plants were perched above the soil on rootstocks. Unable to make good contact with the soil, they could not form roots and develop to form the auxiliary shoots that grow to form new fans.

Among the Lincoln plants, Warwick encountered the first significant insect pest of the evaluation. This was a mealybug (*Balanococcus diminutus*) that prefers

Sue Scheele records growth of harakeke at Lincoln.

Flowering

The kōrari is the flowering stem (peduncle) of harakeke. The 'branches' that go off the main stem, and bear the flowers, are called secondary peduncles.

Flowers do not open all at once. In fact, their opening spreads over about 6 weeks. Each individual flower has both male (pollen in pollen sacs) and female (ovaries with a style and stigma to receive the pollen) parts.

So do the flowers pollinate themselves? No. When a flower first opens, it pushes out its pollen sacs. The female parts remain below the sacs, and are not even ready to receive pollen until most of the pollen is shed.

The flowers are designed to be pollinated by nectar-feeding native birds – tūī, korimako (bellbirds) and pihipihi (waxeyes). Today, starlings and mynahs are also frequent visitors. When a bird visits a flower, it pushes its beak down into the flower tube to feed on the nectar. If the pollen is being shed on that flower, it brushes onto the top of the bird's head. The pollen is then transferred to the next receptive flower the bird visits – that is, a flower where the pollen has already been shed, and the stigma and style (female parts) have pushed forward to collect the pollen. The fertile pollen travels down the style to the ovaries at the base. The fertilised 'eggs' or ovules then develop into seed, contained in the pod that develops from the flower.

Because flowers on the same kōrari develop at different times, couldn't a visiting bird pollinate flowers on a harakeke bush with its own pollen – that is, self-fertilise the plant? Is there any advantage in a harakeke plant being pollinated from another bush?

Ecologists John Craig and Ann Stewart carried out some experiments on harakeke reproduction and found out that harakeke is largely 'self-incompatible', though it is capable of producing a few seeds on its own. Perhaps compounds exist in the flowers that inhibit the development of plants of the same genetic composition. Seeds produced from outcrossed flowers (where pollen comes from a different plant) are much more numerous and are larger than those produced by flowers from different kōrari on the same bush. In turn, the latter seeds are larger than those produced from flowers on the same kōrari.

There are likely to be **some** changes though, in genetic composition, even in the course of vegetative reproduction. For example, we have noted elsewhere that the striking variegated harakeke *Parekoretawa* has, on some fans, reverted from yellow stripes to green.

Warwick Harris carried out a seed survey of the 12 Lincoln trial plants, three ornamental wharariki (*P.cookinaum)* and a 'non-weaving' harakeke, in 1999. One aspect of interest was the comparison of seed weight per 100 seeds. Whahariki seed is much lighter than harakeke seed. The varieties *Paoa* and *Oue,* perceived as likely hybrids between *P. tenax* and *P. cookianum,* had the lowest weights of the trial varieties.

harakeke as its host. It is usually noticed living amongst a mass of whitish-grey powder at the base of the fans. It appears that grass clippings thrown on to the base of the plants when the grass strips are mown encourages this mealybug. It has a close relative that infests tī kouka.

There was a range of responses to winter cold damage in 1997, with three plants severely damaged, 19 showing no signs of damage, and the rest in between. It was noted that the smaller border plants, which had been planted later, had their rito leaves killed by frost. As the plants grow larger, they should provide more self-protection for the soft emerging rito.

The first kōrari appeared in the summer of 1997/98, on five plants of five different varieties – *Kōhunga*, *Māeneene*, *Ngaro*, *Tapamangu* and *Tāpoto*. In most other places, *Paoa* was the first to flower. The summer was dry, but rainfall came at regular intervals, so growth was good – average blade length increased from 113 (spring 1997) to 131 cm (autumn 1998) and average basal circumference from 65 to 84 cm. There was quite a lot of dead leaf, probably induced by the dry conditions.

In spring 1998, it was noticed that most plants had some leaf scorch from the

combination of cold temperatures and sunburn. Only four plants, two each of *Ate* and *Oue*, showed killing of rito leaves by cold. These were smaller plants where the older leaves did not give protection to the young emerging rito.

By the time of the final measurement in spring 1999, the plants had made good growth. Plants of *Arawa*, *Hūhiroa*, *Ngaro*, *Parekoretawa*, *Paretaniwha* and *Tāpoto* were entirely healthy. The floppy-leaved varieties *Kōhunga* and *Māeneene* showed sunburning where their leaves bent. *Kōhunga* also had some brown leaf spot. *Ate*, *Paoa,* and particularly *Oue,* showed some leaf break and striping, indicative of slight cold damage. *Tapamangu* and *Ate* showed leaf yellowing. This yellowing has become particularly marked for two of the three *Ate* plants during summer and is causing premature death of leaves.

The plants had made steady progress in their size — mean leaf length increasing to 165 cm and average basal circumference to 128 cm. They were thoroughly trimmed after the measurements were completed.

Sunburn on leaves.

Base of the flowering fan of Tapamangu. After kōrari has set seed its supporting fan dies.

Grass trimmed and pulled back from matting, Taumutu, spring 1996.

Taumutu

This site is even drier than Lincoln, as it is on shallow, sandy soil. To help the harakeke establish, water was bucketed to the plants by Warwick and Cath Brown on visits over the first summer. All plants established and survived through the 1996 winter, and there was only light damage to the rito leaves from frosts. In spring, 20 plants had more than one fan (average 2.1).

There is a lot of variation in the depth and sandiness of soil at this site, which was made evident by the pattern of plant growth over the following seasons. Grass growth was luxuriant following the winter rains of 1997, though more harakeke was damaged by frost. Shelter from the macrocarpa adjacent to the planting appeared to offer protection to the harakeke closest to these trees.

The fertilizer applied to several of the plantings.

The summer of 1997/98 was very dry, and the plants made little progress. Mean leaf length increased from 84 (spring 1997) to 88 cm (autumn 1998) and average plant circumference from 42 to 48 cm.

In one part where there is either deeper soil or a seepage, several of the plants grew strongly. By spring 1998, differences in the growth of the plants caused by soil variation became more marked, with some plants strongly growing with many fans, and others struggling to maintain their original single fan.

Superphosphate applied to the border plants appeared to have made the grass growth even more vigorous, but the harakeke plants did not seem to be responding. However, because of drought

Strong harakeke at Taumutu growing where the soil is deeper.

Trimming the long grass around the harakeke at Taumutu.

conditions, much of the super still lay on the soil surface.

With more rain over the following summer (1998/99), the plants made slow but steady progress. Average leaf length increased from 86 to 97 cm and basal circumference from 57 to 63 cm during the summer. *Ngaro* had the longest leaves at 141 cm while those of *Oue* were only 50 cm long.

A lot of earwigs and slaters were seen, but they seemed to be using the plants for shelter rather than food. Otherwise, there was no sign of pests and diseases on the plants.

All plants survived to the final measurement in spring 1999, but the difference between the smaller and larger plants became progressively greater. A plant has generally reached a size able to sustain harvesting when it has a basal circumference of 100 cm. Five plants reached this size at Taumutu and about the same number were close to it. By contrast, two of the *Oue* plants remained very small, one with one fan and the other with two fans.

Kaiapoi Pā

By autumn 1996, all the plants had established and produced new leaves, aided by the high water table in the area. There was a large dieback of rito leaves (55%), possibly caused by a late frost the previous spring.

Weed matting was not used at this site. Unfortunately, twitch and Californian thistle soon grew up through the bark and paper mulch, and a lot of effort was always needed to remove the weeds from around the plants.

In spring 1996 (mid-October), considerable frost damage was seen on the rito leaves. New rito were emerging, but Erena later reported that these leaves were severely cut back by a late frost. Twenty-one plants had more than one fan (average 2.2). The frost damage was still evident the following autumn, though the plants were generally well established.

Leaf growth at Kaiapoi Pā was cut back by winter cold damage.

By mid-October 1997, there was no sign of spring growth for any of the plants and they were still showing all the effects of a cold winter. All of the plants showed moderate to severe frost damage, with 23 of the 34 surviving plants having a cold damage score of 3, the highest score on the 0–3 scale.

In autumn 1998, soil conditions were very dry, the plants had a lot of dead leaves, and most of those still alive showed signs of frost damage from the previous winter. The dead leaves were left on the plants, and tied up to provide some protection to the young leaves. Measurements showed that the plants had made no progress during the summer. Eight had died and several more were so weak that it was unlikely they would survive another year of similar conditions at the site.

By spring 1998, all the surviving 27 plants showed cold damage, in most cases severe, although the tying up of leaves in the autumn had to some extent protected the *rito* leaves, especially on bigger plants. A lot of mature leaves had died as a result of

the drought. Consequently, basal circumference had fallen from 51 (autumn 1998) to 44 cm, together with a decline of fans per plant from 5.7 to 5.4. Average leaf length had declined to 70 cm, which is markedly less than the average length of 86 cm at planting.

The following autumn, four more of the plants had died, but another that had appeared dead in spring was alive but very weak. This left 24 living plants. All three *Hūhiroa* plants were dead and *Arawa*, *Paoa* and *Paretaniwha* had been reduced to one living plant each. The stronger surviving plants had made new growth in recent weeks, but this was soft and likely to be cut back by early frosts as had happened in previous years. Without weed matting, the weaker plants had also been prone to smothering by weeds that had grown through the mulch.

By the final measurement in spring 1999, only 16 of the original 36 harakeke remained in a state where they could be measured. Once again, plants had suffered severe cold damage during the winter, destroying most of the growth they had made in autumn after a very dry summer. Smaller plants were much more susceptible to cold damage and competition from grasses and weeds. It was also observed that the soft young leaves of weakened and shaded fans had been chewed by slugs, further limiting their chances of survival.

Leaf dieback caused by hard spring frost, November 1996.

All plants of *Hūhiroa*, *Oue*, *Paoa*, and *Paretaniwha* were dead or almost dead. Only *Māeneene* and *Tapamangu* had all their plants survive, and *Tapamangu* did remarkably well for the conditions. It had the longest leaves (103 cm) and greatest basal circumference (77 cm) of the plants at this site.

The observation that *Tapamangu* and *Māeneene* appear to be better adapted to survive such conditions is reinforced by the performance of the four varieties planted as border plants. Of the four border plants of *Tapamangu,* three survived and two of them were strong, whereas the three remaining *Paretaniwha* of the four planted were very weak. There were 18 border plants each of *Māeneene* and *Arawa*. Of these, 14 of the *Māeneene* survived, nine as strong plants, whereas of the 12 *Arawa* plants that survived, only five were strong plants.

Sue Scheele and Morehu Henare release harakeke from the grass.

Warwick Harris with plant tied up to protect young leaves from cold damage.

Only a few harakeke at Kaiapoi grew above the enveloping grass.

Erena McNeill trims dead leaves from harakeke at Kaiapoi.

Relocated plants at Otākou Marae well established after their summer growth.

Otākou

At the autumn 1996 measurements, there were signs that cattle had been in the area. Fortunately they had not damaged the harakeke. However, it was clear that, without grazing, rank grass and scrub would soon get away in the fenced area and it was too large an area to keep clear by mowing. Marae management resolved this concern and organised for the plants to be moved to a site close to the marae office.

Of all the sites, the plants at Otākou had made the least growth, but the original leaves showed less dieback than most other sites. Lower summer temperatures at Otākou may have slowed the growth of the plants and lessened the effects of drying that have probably caused leaf dieback at other sites.

By spring 1996, Ron Stevens and Doug Ditfort had shifted the plants. The layout pattern was different, but still fitted experimental requirements. Even though this is the southernmost site, its position on a north-facing slope by the sea has prevented frosts severe enough to damage the plants.

By autumn 1997, all of the plants except two (accidentally cut by the mower) had re-established well. The following spring, observations showed no sign of cold damage over the winter months. Indicating that the plants were well re-established after their shift, the number of fans increased from 2.5 to 4 per plant over winter, and there was an increase of blade height from 83 to 88 cm.

The plants made steady growth throughout 1998. In spring, the average basal circumference was 67 cm, average leaf length was 116 cm, and the plants were well on the way to reaching a size for sustainable harvesting.

At the autumn 1999 measurement, it was clear that plant growth had been slowed by a dry summer. The soil is sandy, and with the planting being on a warm slope, it was easily affected by dry conditions. Nonetheless, the planting was in excellent shape. Ron Stevens had trimmed the plants, cultivated around them, and cut the kōrari off. The kōrari on the three *Paoa* plants had been cut in spring, and leaf growth had benefited from this. Ron said that the development of tall kōrari on some of the plants, particularly those planted on the bank, had threatened to tip them over and

Parepare (palisade) adds to character of planting at Otākou.

Ron Stevens kept the trial in excellent order.

expose their roots.

At the final measurement in spring 1999, the plants were well weeded and trimmed as usual. Herbicide had been used along the fence line next to the planting and also around the plants. Leaf crinkle of young leaves, especially on new fans, indicated some damage to the harakeke from the herbicide used. Hopefully this will only have a short- term effect on the plants.

In general, the plants were healthy with just minor signs of leaf notching, windowing and brown spot. Fourteen of the plants had a basal circumference greater than 100 cm, the size able to sustain harvesting. Warwick cut off the new kōrari on the *Paoa*, and applied fertiliser to each plant.

Noel Eden kept the Omaka site well watered and mown.

Omaka

The plants established well, aided by a wetter than usual summer and some watering. Survival of the original leaves of the planted fans, recorded in autumn 1996, was better at this site than at all other sites.

By spring 1996, the planting was still progressing well although there had been some frost damage. The plants had been watered regularly and the grass around them was well trimmed. There were 27 plants with more than one fan (average 2.8).

It was obvious a year later that the plants at Omaka would not have made much progress without watering. Marlborough had endured a prolonged drought, and the site itself is on stony, dry soil. There was light frost damage to 21 of the 36 plants. All the plants of *Arawa*, *Kōhunga*, *Ngaro*, *Oue*, *Paoa* and *Paretaniwha* showed some damage, whereas *Hūhiroa*, *Māeneene*, *Parekoretawa*, and *Tapamangu* were all undamaged. The *Oue* plants all showed distinctive brown striations on their leaves. This was a characteristic of this variety at the other cold sites.

Watering carried the plants through the next dry summer, though there were a lot of dead leaves at the autumn 1998 measurement. Plant circumference changed little between autumn and spring 1998 (67 to 70 cm), and the average blade length was the same at 106 cm. There was no sign of cold damage, soil moisture levels were good, but the leaves of most plants were overly yellow. This suggested that soil fertility was holding back their growth. Noel Eden thought that the weed matting was restricting water getting to the roots of the plants, so the process of pulling off matting and loosening the soil was started.

With the help of watering by Noel over summer the plants made steady growth, though again, the amount of dead leaf indicated that the plants had suffered some drought stress.

By the final measurement in spring 1999, the plants ranged from green and healthy to stunted and yellow. This largely followed the variation of soil in the area of the

Removing the matting from around the plants.

Kath Hemi and Margaret Bond with one of the stronger harakeke at Omaka.

planting, one end being particularly drier. This tended to mask the differences between the varieties. However, all plants of *Oue* were especially stunted at this site and had noticeable brown lesions on their leaves, and all the *Arawa* plants had bronzing of their leaves. The leaf notcher showed its presence on two of the plants, but otherwise the plants were free of pests and diseases.

The plants had made a small progress in their size from the autumn measurement, leaf length increasing from 120 to 121 cm and basal circumference from 81 to 84 cm. NPK fertiliser was applied to each plant.

Warwick made a quick visit to the planting when in Blenheim early in January 2000, and it was a pleasant surprise to see that an overhead irrigation system had been erected. The plants were showing a good growth response to the fertiliser and watering.

Oue showing brown striations typical of plants of this variety at frosty sites.

Tanenuiarangi Inc.

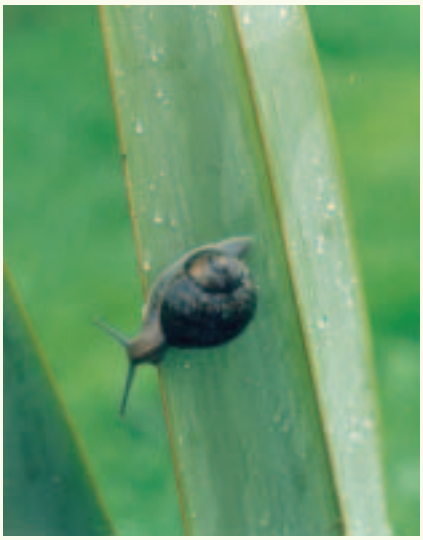
The visit to Tanenuiarangi in spring 1996 showed that all the plants except one had established well since their planting 6 months earlier, and they had escaped frost damage. This is a lush site for both grass and harakeke with good soil and plenty of rain. It is also good for snails, and Warwick picked a lot off the plants on various visits.

By autumn 1997 the harakeke at Tanenuiarangi had already caught up in size to plants at many other sites. By spring, the number of fans per plant had increased to 4.3, and average blade length to 108 cm.

The plants continued to grow strongly. The spring 1998 observations showed no cold damage to the plants and the soil was moist and friable. There was some sign of 'window' damage, notably on the *Māeneene* plants. Snails were numerous but they did not appear to be causing damage to the plants, mainly using the harakeke for shelter. The average basal circumference had increased markedly from 72 to 88 cm over winter, although the change of mean leaf length from 136 to 137 cm was small.

Growth slowed somewhat over the very dry

Vigorous harakeke at Tanenuiarangi, spring 1999.



Snails thrive under moist and mild conditions.

Watering has ensured the plants have made steady progress at Omaka.

Harakeke at Omaka framed by an overhead irrigation system.

Tahi, Dallis and Summer Meihana tidy up the planting in spring 1996.

The harakeke at Tanenuiarangi are growing quickly.

Ivon Harris speaks at the passing over of the harakeke trial to the care of Tanenuiarangi.

summer of 1998/99. Even so, the average leaf length had increased from 137 to 164 cm and circumference from 88 to 106 cm. *Kōhunga* had the longest leaves at 199 cm and *Parekoretawa* the shortest at 107 cm. The leaves of the *Oue* plants at this site were unusually long relative to the other sites, and measured 146 cm.

By spring 1999, the harakeke had obviously benefited from a wet, warm winter, and their growth was lush. There had been considerable developments at the marae since the previous visit, and widening of the entrance road into the marae required two plants, *Māeneene* and *Paritaniwha,* to be shifted to the other side of the drive.

In general the plants were healthy and vigorous although there were signs of leaf notches and windows, bronze-burning of floppy-leaved varieties, and a little leaf scale. Although leaf length had increased only from 164 to 165 cm, there was a large increase of the basal diameter of the plants from 106 to 126 cm. The beginning of prolific flowering by the *Paoa* plants was underway, the three plants having 5, 4, and 12 emerging kōrari.

In June 2000, a ceremony was held at Tanenuiarangi to formally hand over the care of the trial harakeke to the marae. Nikau and tī pore plants were presented to the marae, and Warwick, in turn, was gifted a framed carving in appreciation of all his efforts in establishing the pā harakeke and other plantings.

Otatara

By autumn 1996, bark had been spread around the plants at Otatara, and the plants were well watered as a trickle irrigation system had been installed. The warm and sheltered situation and the watering had ensured that all but one of the plants were firmly established and most

were growing well even though the subsoil conditions are difficult. With watering, weed control by bark and herbicide spraying, and no frost damage, the plants progressed over winter. By spring 1996, 31 plants had more than one fan (average 3.4).

At the spring 1997 measurement, it was raining steadily, and slugs and worms were seen crawling over many of the harakeke. There were also clear signs of 'window' and 'notcher' caterpillar damage on several plants, as well as mealy bug, ants and spiders. Of particular interest was the first example of a plant that had established well and then died. This was a *Hūhiroa* plant that had developed seven fans but which had been recorded in autumn as having signs symptomatic of yellow leaf disease. However, this plant was in a part of the site where drainage was particularly impeded because of the compacted subsoil, and this is the most likely cause of the plant death.

Serious drought affected the region in the summer of 1997/98, and there were a lot of dead leaves to trim off in the autumn. However, trickle irrigation had protected the plants and their mean leaf length increased to 141 cm. Average basal circumference was 91 cm.

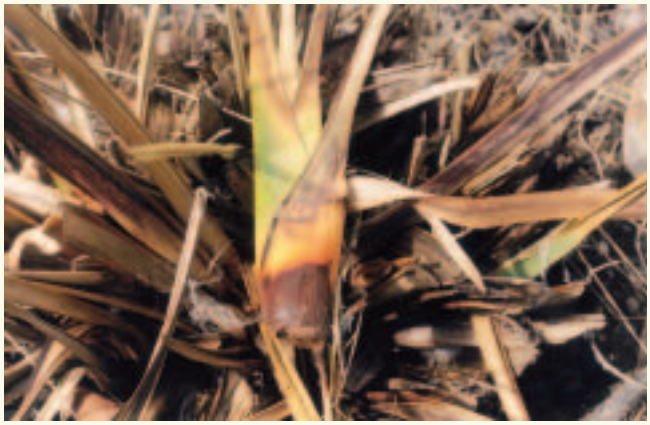
By spring 1998, many of the plants had a high proportion of yellowing leaves and, again, there were a lot of dead leaves to trim off. *Tapamangu* in particular showed these characteristics. These effects were probably caused by the dry conditions at the site. The pipe to the trickle irrigation system had been cut, probably by a weed eater. This was repaired and the irrigation turned on to give the plants a good watering.

In looking for pest and disease symptoms we noticed brown spots on the butts of the leaves and also on leaves of the floppy-leaved varieties where they drooped to ground level. This was a puzzle as it did

Otatara trial. Dying Hūhiroa plant in foreground.

Jody Stent trimming dead leaves.

Warwick Harris measures the basal circumference of a *Paoa* plant, Otatara.



Some fans at Otatara show this basal rot.

Spots at base of plant caused by damage from Preglone spray.

not conform to the various disease and pest symptoms we knew. Later it was realised that the damage was tissue burning caused by a desiccating herbicide, Preglone, applied for weed control. Fortunately, Preglone is not moved around in plant tissue, and the herbicide did not have a long-term effect on harakeke growth.

In autumn 1999, most of the plants were vigorous and healthy, but six previously well-established plants had been severely set back, and three of these were dead. Two plants each of *Paretaniwha* and *Tapamangu* and one plant each of Arawa and *Hūhiroa* have been affected. The most likely explanation is that the plants died from impeded drainage. Although thought of as swamp plants, most harakeke do not like standing in stagnant water, and they do best in moist but free-draining soils. Another possibility is that the plants were affected by long-lasting herbicide, or some other chemical draining from the brick-paved area above the planting. The situation of the affected plants on the site supports this possibility.

At the final measurement in spring 1999, we observed marked variation in the vigour of the plants relating to the variation of the soil. The plants were large and green at one end, and small and yellowing at the other. A further *Tapamangu* plant was dying, leaving only one vigorous plant of this variety. This plant, and a plant of *Paretaniwha* recorded as dying at the previous visit, showed similar rotting at the base of the fans that preceded the death of the leaves above this. There were signs of this base rotting on an *Oue* plant also. However, another plant of *Paretaniwha* that had shown similar dieback was showing good recovery from young fans.

There was some leaf bronzing indicating sunburn and possibly cold damage, but no obvious sign of pest and disease damage, although notches and windows are prevalent on older harakeke planted near by.

Ate, one of strongest plants at Ohakune, was still damaged by wind and cold.

Maungarongo Te Marae, Ohakune

Ohakune was clearly the most difficult site for the harakeke. In autumn 1996, long grass had grown between the plants and over the weed matting. It probably provided some protection from the cold mountain winds that had split and shredded most of the leaves on the harakeke. However, all the plants had survived and made new growth over the summer. The original fans had grown an average of four new leaves and nine plants produced new fans. Forty-seven percent of the matua leaves and 14% of the rito leaves were more than half dead.

The plants were very severely damaged by cold the following winter. Most of the rito leaves and many of the matua leaves were largely dead. Several of the plants appeared to be completely dead, though closer inspection showed most still had living tissue at their bases. Eleven plants had more than one fan (average 1.4).

Three plants died over the summer of 1996/97 and at the autumn visit several other small, cold-damaged plants were very weak, as they had been smothered by tall grass. However, most of the plants had leaves standing out above the grass, and should have been better able to withstand the next winter's cold.

In spring 1997, the harakeke were in very poor state. All except one of the remaining

26 plants showed cold damage, in most cases severe, completely killing the rito. Cattle had also chewed the remaining good leaves. There was no increase in the number of fans, and the mean blade length had decreased from 93 to 84 cm during this period, showing the effect of dieback from cold and chewing of the upper leaf parts by cattle.

A new kura was planned for the planting site, but because building was delayed, the opportunity came for one more measurement a year later, in spring 1998. No further plants had died. There had been an increase of average basal circumference from 27 to 34 cm, the number of fans per surviving plant had risen from 2.1 to 2.8, and leaves had lengthened from 87 to 91 cm, only a little longer than the 84 cm on planting. Cold damage, in many cases severe, was noted for all plants except two that had probably been protected by long grass. The long grass had been responsible for smothering and weakening the harakeke earlier in the evaluation, and a few of the plants had been weakened further by this effect. The leaves of most of the plants had been chewed by cattle, exposing the muka.

Obviously, the local stands of harakeke consist of plants that are adapted to the cold climatic conditions and naturally infertile soils of the region. From the information we have about the origins of the weaving varieties, and the responses to cold damage that have been observed, it seems that most of them come from lower altitude, coastal areas of the North Island.

Freezing resistance of native plants

The ability of plant species to avoid damage from low or freezing temperatures is of key importance in determining their natural areas of distribution.

Among the most cold-sensitive of New Zealand plants is mānawa, the mangrove, which grows on muddy shorelines no further south than Kawhia on the west coast, and Bay of Plenty on the east coast of the North Island. Mangrove fails to survive at -3°C.

The most freezing tolerant of New Zealand plants are the coniferous subalpine shrubs such as the mountain toatoa (*Phyllocladus alpinus*), tauhinu, the snow totara (*Podocarpus nivalis*), and bogpine, (*Halocarpus bidwillii*). These species can tolerate temperatures as low as -20°C.

Most New Zealand trees and shrubs fall between these two extremes. They can withstand some freezing without damage, but mostly not more than -10°C. Species, and plants within species, vary in the amount of freezing they can stand before they are damaged. This is related to where they occur naturally. For example, mānuka raised from seed collected in North Auckland is more susceptible to frost damage than plants raised from seed collected from subalpine stands in the South Island.

The frost damage to the harakeke in the weaving variety evaluation was unexpected, but it suggests that this species shows the same variation to frost resistance in its wild populations, as has been shown for mānuka. The observation that all of the trial harakeke suffered cold damage in the early stages of growth supports the conclusion that they originated from warm lowland and coastal parts of the North Island.

Ruamata

The harakeke is surrounded by an area of tall weeds, most notably wild parsnip and blackberry. At times, over the course of the 6-monthly visits, it took considerable effort to clear the weeds from around the harakeke – especially the blackberry. All except a plant of *Paretaniwha* were making new growth at the time of the autumn 1996 visit.

As part of the trial's community focus, Warwick visited the Kura Kaupapa to talk

Autumn 1996, the plants at Ohakune have established well.

The harakeke at Ohakune were further weakened by cattle grazing.

Harakeke can grow well on the cold Volcanic Plateau.

The rito of this *Arawa* plant has suffered frost damage.

about the experiment. He gave the school a plant of tī tawhiti, a traditional variety of cabbage tree used for food.

At the spring 1996 visit, Warwick had a welcome visit from Emily Schuster and, later, her husband Bob, who tidied up between the plants with his weedeater. The harakeke had been damaged by frost, some quite severely, and had made little growth since the autumn. Seventeen plants had more than two fans (average 2.1).

Over the summer, the plants made steady progress, but some were later damaged by the winter cold. In spring 1997, 11 of the plants showed no damage, including all the plants of the varieties *Ngaro* and *Parekoretawa*. The varieties showing the most severe damage were *Paoa*, *Arawa* and *Ate*. There was little sign of insect damage, or other invertebrates apart from a few worms and slugs. Perhaps the pūkeko account for this? Pūkeko were always around the planting. They seemed to use the weed matting as a surface on which to break open the freshwater mussels they brought out of the lake.

Growing conditions over the summer of 1997/98 were good, and the average leaf length had increased from 97 (spring 1997) to 114 cm (autumn 1998) and plant circumference from 48 to 61 cm.

At the spring 1998 visit, plants showed little growth, though a kōrari was observed on one of the *Paoa* plants. *Ate*, *Oue* and *Paoa* were the varieties most affected by the winter cold.

The harakeke again made good growth over the summer of 1998/99. As for many of the plantings, *Ngaro* had the longest leaves at 166 cm and *Oue* the shortest at 64 cm. The plants were in good health without any obvious damage from pests and diseases.

At the final measurement in spring 1999, the plants were shown to be continuing their steady progress, with leaf length reaching an average of 137 cm, and basal circumference 91 cm. Soil phosphate (P) levels at this site are low, and applying

Ruamata, autumn 1999. Blackberry encroaches on the site.

Phormium leaf spot is very marked on the *Arawa* varieties at Ruamata.

Removing kōrari – yes or no?

Opinions vary on whether it is best to remove the kōrari as they emerge in late spring.

The production of the flowering stem does take the plant's energy away from leaf growth, so it could be worthwhile to do so, especially in those varieties such as *Paoa* that produce a lot of kōrari every year. During the evaluation trial, the kōrari were cut off at Otākou just as they were emerging from the fan leaves. At Lincoln, the kōrari were left until they formed mature seed. In measurements made in autumn 1999, it was observed that leaf growth on *Paoa* was much better on the Otākou plants than on those at Lincoln.

Nonetheless, the kōrari and flowers are distinctive and beautiful, and create a lovely spectacle in a good flowering year. And they are a wonderful source of nectar for tûî and bellbirds and other nectar-feeding animals.

If removing kōrari in spring just as they are beginning to develop, Warwick suggests you don't cut the leaves at the base of the flowering stem. The photosynthesis by these leaves, and the transfer of mineral nutrients from them to other fans in the plant, will help the growth of the whole plant. This will also assist the development of one or more new fans at the base of the flowering fan. A flowering fan is destined to die and its dead leaves and stump can be cut away when the bush is pruned.

Harakeke with tall kōrari.

fertiliser would undoubtedly increase the size and quality of leaves.

Brown spot was present on most of the plants, but especially marked on *Arawa*. All the plants of *Māeneene* had a small amount of window damage, but only two other plants of other varieties showed this effect. All the *Oue* and *Paoa* plants, and two of the *Ate* plants, showed leaf-break and leaf-striping symptomatic of cold damage.

UNITEC

Auckland's wet summer, warm temperatures, and the fertile soil, combined with the pampering of bark mulch and assiduous weeding, meant that the plants here put on far more growth than at other sites. At the autumn 1996 measurements, the original fans had formed an average of seven new leaves, and 27 of the plants had formed new fans, with *Paretaniwha* having 10 fans.

The plants continued to grow considerably over winter, had no frost damage, and at the spring 1996 measurements, all 36 plants had more than two fans (average 6.8). The blades averaged 107 cm, markedly longer than the 82 cm at planting.

With the plants growing so vigorously, the weed matting was removed in autumn

Bob Schuster trims weeds between the harakeke, spring 1996, Ruamata.

Harakeke were surrounded by water following heavy rain at the time of the spring 1997 measurement.

Well trimmed plants at Pā Harakeke Rangimarie show the beauty of their forms. L to R: Māeneene, Parekoretawa, Tapamangu.

Measuring the circumference of the harakeke.

Measuring the width of the leaves.

Students harvesting leaves at UNITEC.

1997. Counting the fans was difficult, as some plants had more than 50.

In spring 1997, students took part in the measurements and trimming of what were now large harakeke plants. Henare Te Ua met Warwick at the planting to gather material for an item on the harakeke evaluation trial for National Radio's Whenua programme. Manaaki Whenua staff Rau Kirikiri and Ross Beever came along too, and there was an unexpected visit from Saana Murray, adding to a hectic day.

By autumn 1998, the plants were so large that Warwick had to crawl around them to measure their circumference, and one was larger than the 200 cm length of the tape. Over summer, mean leaf length had increased from 146 to 199 cm and circumference from 123 to 154 cm.

At the spring 1998 visit, the morning was devoted to the ceremony of passing over the planting to the care of Pūkenga, and to talks given by Warwick and Sue Scheele to the staff and students. The ceremony was led by Haare Williams, and a plaque was unveiled to mark the dedication of the pā harakeke to the memory of Dame Rangimarie Hetet.

The measurements we made in the afternoon showed the plants had continued to grow over the winter, with basal circumference increasing from 154 to 218 cm and leaf length from 199 to 205 cm. The development of kōrari on all three *Paoa* plants was well advanced, but none were apparent on the other varieties. After a discussion with Kahu Te Kanawa these kōrari were left on the plants. Kahu said that her family's practice was not to remove the kōrari when harvesting.

By autumn 1999, average leaf length had increased considerably, from 205 to 242 cm. When held up from their very droopy disposition, the leaves of *Kōhunga* were the longest at 285cm, more than 2.5 times the length of the short, stiff *Oue* leaves, which measured 107cm.

In spring 1999, The *Pā Harakeke Rangimarie* was visited after a wet night. The plants were in a variety of conditions according to their use and care. It appeared that some varieties had been targeted for harvesting, and in particular the three *Paoa* plants had been overharvested. On the other hand some varieties appeared to be neglected as they are more difficult to keep trimmed, *Māeneene* providing the best example of this.

Brown spot, circular black mould and scale insects, evident as crusty white clusters, were widespread amongst the plants, but much less so on plants that had been correctly harvested and pruned. Scale and moulds are encouraged by shady conditions and moist and humid weather. It appeared that the plants had reached their maximum size.

Gathering of people after the dedication of pā harakeke Rangimarie at UNITEC.

Plaque dedicating pā harakeke to Dame Rangimarie Hetet.

Protecting harakeke from insect pests and diseases

In traditional practice, any unneeded trimmings from harakeke are placed back under the bush from which they came, thus creating a mulch and returning nutrients to the earth. It is one of the rituals surrounding harakeke that reflect the high value of the plant and the respect with which it is used.

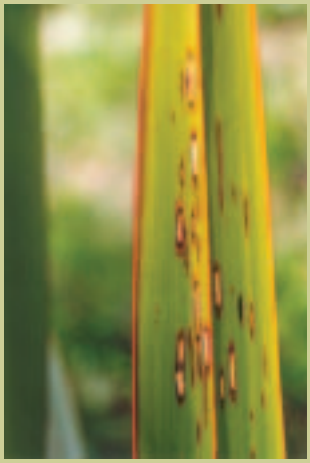
However, in our modern-day environment, where pests and diseases and their natural controls are often out of kilter, this practice is often damaging to the good health and vigour of the plant.

Dead leaf material provides a perfect daytime shelter for the 'windower' and 'notcher' caterpillars, which come out and feed at night. Unwanted leaves and trimmings should be composted or buried well away from the harakeke bushes.

Scale infestations are not uncommon on harakeke, especially where the plants are shaded. The scale forms white, crusty patches on the underside of the leaves. The insects suck sap from the leaves, and the upper leaf is left discoloured with purple and yellow blotches. The fibre is generally weakened and the leaves are more susceptible to disease. Oil sprays can be used to help control the infestation, but affected leaves should be removed and burnt.

Fungal rusts and moulds can discolour and damage leaves, especially in warm, humid areas. Leaves that are seriously affected by fungal diseases should be removed and preferably burnt. This is because the disease spores can remain viable and travel some distance to reinfect plants.

Scale damage.



'Windower' damage.

Leaf showing 'notcher' damage.

A well-trimmed harakeke, free of debris.

Kaitaia College

Rainfall in North Auckland had been plentiful over the summer and all 36 plants at Kaitaia had established well by autumn 1996.

At the spring 1996 measurement, the plants had grown and showed no sign of frost damage. Twenty-two of the plants had more than two fans (average 2.3). Warwick gave a talk to the Bilingual Class, now fourth-formers, who had planted the harakeke. They had grown more than the harakeke plants in the year since he had last seen them! Warwick's talk was rewarded with a waiata about Hone Heke.

The plants survived over the 1996/97 summer, though did not make as much growth as expected given the warmth and moisture of this site. This was probably due to the soil fertility limits of the gumland soil.

By spring 1997, there was a small increase in the average number of fans per plant from 2.9 to 3.5. However, blade height had changed little, with the average height in autumn 1997 being 99 cm and in spring 100 cm.

The growth of the harakeke at Kaitaia was markedly held back by low soil fertility. As a preliminary to altering this later on in the evaluation, 100 g of superphosphate was spread around each of the border plants. Low soil fertility kept the plants just ticking over. During summer, leaves barely increased in length from 100 to 101 cm and circumference from 45 to 50 cm. The sandy soil was very dry. Much of the superphosphate applied at the previous visit was still on the soil surface. However, there was some indication that the border plants were beginning to respond to the fertiliser.

A paper written in 1945 by T. Rigg and J. Watson describes the results of fertiliser application to harakeke grown on acid pakihi soils near Westport (*Phormium tenax* manurial and cultural experiments at Westport. *New Zealand Journal of Science and Technology 27A*: 336–342). With no fertiliser, 4000 pounds green weight of flax was obtained from an acre, applying phosphate gave 91,000 pounds, and a complete fertiliser with phosphate, potash and nitrogen gave 118,000 pounds. If the low phosphorus levels of the Kaitaia College site were corrected, the plants should markedly increase their growth.

Harakeke are healthy but growth is slow because of infertile gumland soil.

At the spring 1998 visit, the morning was spent in interaction with the staff and students of Te Whare Wananga o Muriwhenua. Sue and Warwick were accompanied to the welcome by Lydia Smith and Florrie Berghan. Amongst those present were Puni Matene, Waitaia and Jean Petera, Louisa Harris, David Crosby, Kumeroa Gregory and Hiki Trethawey.

After the powhiri, Sue and Warwick talked to a smaller group, mostly those involved in the weaving course, about the trial, and insect pests and diseases of harakeke. It was a lively interactive session with interesting questions asked by both younger and older members of the group. Later in the day Lydia Smith, Florrie Berghan and members of the weaving course came and observed the measurements being made on the harakeke.

Lydia Smith and Bruce Gregory gather up cut harakeke leaves.

Lydia Smith tends a Māeneene plant at Kaitaia College.

This single surviving fan of *Oue* at Kaitaia flowered without producing new fans.

The plants had changed little in size during the winter. The three *Paoa* plants all had one developing kōrari each, and these were cut off to reduce the draining of reserves from the small plants. Because of the slow growth of the plants at Kaitaia College, only one new fan seems to replace each flowering fan, and the appearance and growth of these is slow. Florrie spotted that two kōrari were just appearing on one of the *Ate* plants.

There were signs that the border plants were responding to the superphosphate applied to them a year before. The grass around these plants was greener and the nitrogen-fixing legume lotus, which tolerates acid soils, was showing more vigorous growth. There was more new, green leaf growth on the border plants than on the measured plants. Additional fertiliser was applied to give the border plants a further boost.

A busy day at Kaitaia was completed by visits together with Lydia Smith, her granddaughter Maria, and Florrie Berghan to the harakeke collection established by the late Viv Gregory at Roma Marae, the ti pore and harakeke at Ahipara School, and the gumlands of the Ahipara Plateau. Florrie retained a keen memory of the days when there was a large community of gum diggers on the plateau, pointing out where houses once stood where now there are dense stands of white and pink-flowered mānuka.

Kaitaia harakeke established well by spring 1996.

The plants continued to grow slowly over the summer of 1998/99. Most of the plants were healthy at the autumn 1999 visit, although a few had scale insects and mould. The border plants were showing responses to the applications of fertiliser made on the two previous visits. As interest in this planting would wane if it did not grow sufficient leaf for weaving, it was decided to apply fertiliser to the trial plants. Greenleaf Complesal 12N, 10P, 10K was applied at the rate of 250 g per plant.

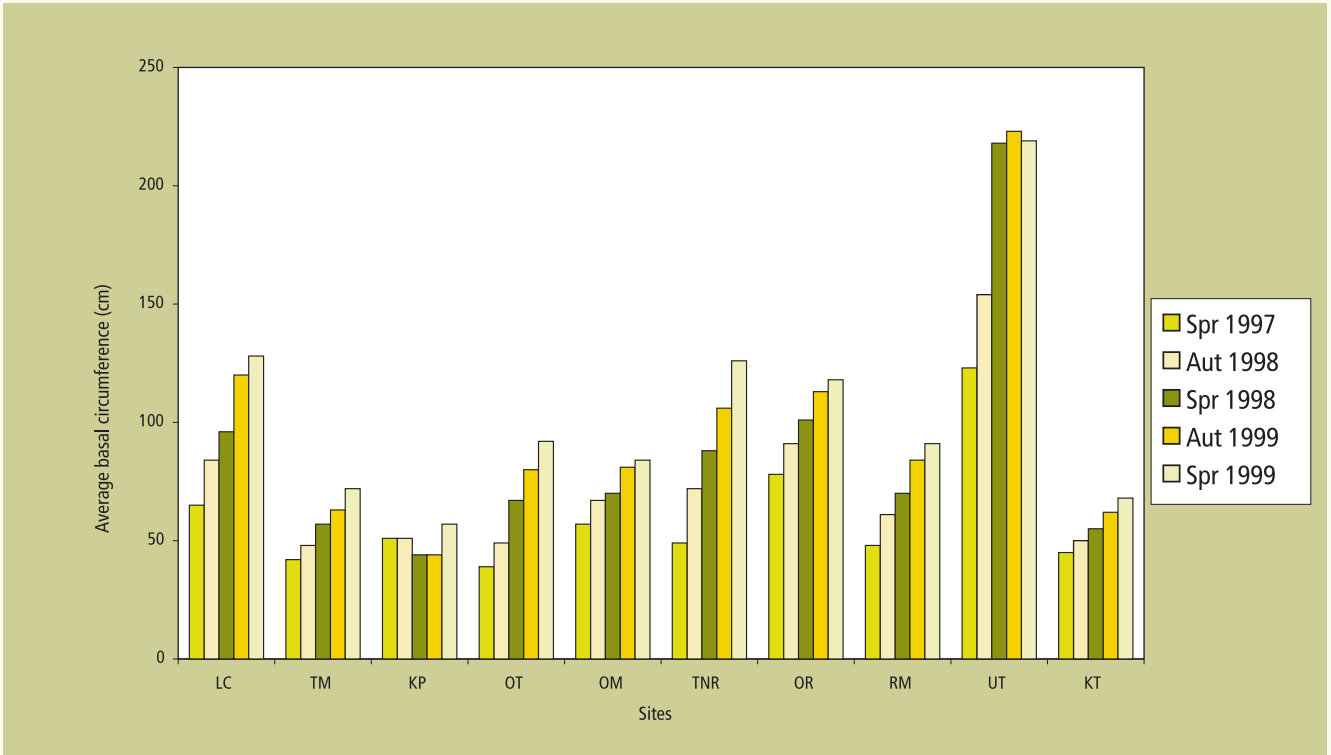
By spring 1999, leaf length had increased to 117 cm, and basal circumference to 68 cm. It is unlikely this growth would have been made if the plants had not been fertilised at the previous visit. There was also an increase of fans per plant from 5.3 to 6.6. Two of the *Paoa* plants had a single kōrari each, and the only other plant showing signs of flowering was an *Ate* plant with two kōrari.

Differences between varieties in the number of fans they have produced, and their flowering, had a large influence on their

performance at this site. The *Māeneene* plants had an average of 23 fans each, whereas the *Oue* plants had only one fan. Since establishment of the planting, all the *Oue* plants have flowered, whereas only one of the *Māeneene* plants has flowered. The single fans of two of the *Oue* plants that have flowered have not had the energy to produce new vegetative fans at their bases. It is likely these plants will die. *Paoa* has a similar characteristic of few fans and a high frequency of flowering, making it a poor variety at this site.

Sue Scheele talks to students of Te Whare Wananga o Muriwhenua about the harakeke varieties.

Average basal circumference of harakeke in evaluation trial Spring 1997 - Spring 1999



Average basal circumference of harakeke in evaluation trial at 10 sites, Lincoln (LC), Taumutu (TM), Kaiapoi Pā (KP), Otākou (OT), Omaka (OM), Tanenuiarangi (TNR), Otatara (OR), Ruamata (RM), UNITEC (UT) and Kaitaia College (KT), as measured 6-monthly from spring 1997 to spring 1999.

Soil fertility and effect on harakeke

Plants vary in their requirements for the elements or soil mineral nutrients needed for growth. New Zealand native plants, in general, have lower soil nutrient requirements than introduced pasture and crop plants. This is because they are adapted to low soil fertility conditions and are mostly slower growing. Compared to exotic pasture and crop plants such as ryegrass, clover, wheat and potatoes, we know very little about the nutrient requirements of harakeke. It is possible that the harakeke varieties, depending on where they originated as wild plants, have different requirements for soil nutrients.

Consequently, we can only make very general comments about how the levels of pH (a measure of soil acidity that affects the availability of nutrients) and the elements P (phosphorus), S (sulphur), K (potassium), Mg (magnesium) and Na (sodium) might influence harakeke growth at different sites.

All the soils lie in the medium range of pH, so the level of soil acidity is unlikely to have had different effects. Half the sites have P values low enough to suggest that the plants would grow better with the application of phosphate fertiliser. Superphosphate contains both phosphorus and sulphur, and would probably be beneficial for those sites with S less than 10. The high S for UNITEC could be from industrial emissions, and for Ohakune from volcanic emissions from nearby Mt Ruapehu.

Generally, if levels of P and S are adequate, then K, Mg, Ca and Na levels are unlikely to be low enough to restrict harakeke growth. The high level of sodium at Taumutu reflects the closeness of this site to the coast and the influence of salt (NaCl) spray.

The sites at UNITEC and Kaiapoi Pā have the most fertile soils, and those at Kaitaia and Ohakune have very infertile soils. Thus, while temperature and moisture availability at Kaitaia are very favourable for harakeke growth, their growth was markedly restricted by low soil fertility when compared with the Auckland site. At Ohakune, the growth of the plants was very restricted by low temperatures and low soil fertility. At Kaiapoi Pā, it seems that frost has acted to hold back growth on what is a fertile soil in the ancient garden area.

Nitrogen (N) is the most important mineral nutrient for plant growth. The levels of N available in soil are changing constantly, and are difficult and expensive to measure. Where levels of the other nutrients are not limiting the growth of harakeke, it is likely that growth would be increased further by the application of nitrogenous fertilisers.

Warwick Harris samples soil at Otatara.

Site	pH	P	S	K	Mg	Ca	Na
Kaitaia College	5.1	4	10	2	23	5	13
UNITEC	5.9	23	101	14	48	10	6
Ruamata	5.7	5	9	18	42	9	8
Otatara	6.1	34	3	13	43	12	5
Ohakune	6.1	2	50	4	15	5	3
Tanenuiarangi	5.7	8	7	10	40	10	6
Omaka	5.6	8	4	8	36	6	4
Kaiapoi Pā	6.3	56	11	14	66	22	9
Lincoln	5.8	12	5	8	26	11	9
Taumutu	5.7	34	11	17	56	5	26
Otākou	5.9	28	7	24	89	11	17

Soil fertility units provided by the Soil Fertility Service, AgResearch, Invermay, from the analysis of the soils of the 11 harakeke evaluation sites.

Harakeke Quality Evaluations

Deciding what to measure

Cath Brown, Ranui Ngarimu, Reihana Parata, Warwick Harris and Sue Scheele got together at Ngāti Moki Marae, Taumutu, on 10 June 1999. The purpose of the hui was to assess the weaving qualities of some harakeke leaf samples and decide on the criteria that should be used on the recording forms to be used in the trial evaluation. We had a most enjoyable day, Cath, Ranui and Reihana preparing samples, while Warwick and Sue learnt which elements it was most important to record, for the pilot study that followed.

Reihana Parata and Ranui Ngarimu at evaluation hui, Taumutu.

Cath Brown.

The Pilot Study

Taumutu, 4–6 October 1999

First, Warwick and Sue harvested four leaves from each of the 36 harakeke plants in the Lincoln planting. The leaves harvested were the 4th youngest leaves on fans, leaving the rito and the two matua leaves. The four leaves from each plant were labelled A B, C and D and numbered according to the order of the plants in the planting layout. Note that the trial varieties are planted in random order, and the samples were not identified by their names.

Sue and Warwick made the following measurements on each of the 144 leaves harvested:

1. Full length of the leaf from the base of the butt to the blade tip.
2. The length of the butt to the beginning of the blade.
3. The length of the butt to the point where it ends to give way to the full width of the blade.
4. The width of the blade from the midrib to the leaf margin at its widest point.
5. The width and thickness (measured with electronic calipers) at the middle of the butt length.
6. For the unprocessed leaf (see below) the blade thickness (using electronic calipers) reading on each side of the midrib at the widest part of the blade.

Margaret Murray, Edna Schuster, and Kahu Te Kanawa (all daughters of the kuia who had been instrumental in establishing the partnership between weavers and scientists early in the 1980s) took part in the weaving evaluation.

We started with a round-table discussion about how the quality assessments should proceed. A scientifically pure approach would have been to get the weavers to work separately from each other, so that one weaver's opinion would not influence that of another. However, it was considered more practical and sociable to work round a table together, sharing opinions on each leaf sample as it was prepared and assessed for its qualities. This turned out to be a very dynamic and constructive procedure.

Margaret prepared strips for raranga, Edna for piupiu, and Kahu extracted muka for

whatu. From the experience of the June meeting, Sue had prepared record sheets with prompts for the weavers to record their quality assessments of the harakeke varieties. Warwick handed out the leaves from each plant, Kahu receiving the A, Margaret the C and Edna the D leaf. The B leaf was kept for later measurements of the unprocessed leaf.

A consistent feature of all three kinds of preparation was to divide the leaf to separate the used portion from the unused parts of butt, keel and leaf margins. Cath had supplied sheep-shearing combs to divide the leaves into equal sized strips. Generally there were two strips for piupiu, and four and sometimes six for raranga and muka. Some samples were entirely unsuitable for piupiu and muka. Each prepared strip was labelled according to the part of the leaf it was taken from; i.e. nearest the midrib, nearest the margin, or the strip in between these. Margaret softened the raranga strips (hapine), the prepared piupiu were boiled by Edna, and Kahu divided and topped and tailed the extracted muka before twisting it into threads (miro).

After each round of preparation the weavers discussed the properties of the variety sample with each other (not knowing the name or origin of the variety) and noted their assessments on the record sheets. For each leaf, the waste material was gathered in one paper bag, and the prepared raranga strips, muka and piupiu were kept separate. Two days were spent preparing and making the quality assessments of the 36 plants.

The processed material was returned to Lincoln. After drying, the weight of the waste material, and useful raranga strips, muka and piupiu was recorded. For the unprocessed leaf, the dry weight of the butt and blade was also recorded. The length of the muka, piupiu and raranga strips was measured, and for the raranga strips, the width and thickness was measured at the base, in the centre, and 3/4 along the length of the strips.

Edna Pahewa.

Margaret Murray.

Kahu Te Kanawa.

All these observations and measurements provided a lot of raw data. When analysed they will tell us more about the characteristics of the varieties, i.e. which ones give the greatest amount of useful material with the least effort of preparation; the length, strength, fineness and colour of muka; suitability for making piupiu for different people; the length, degree of tapering and thickness of raranga strips for different items.

Having worked out the evaluation techniques, we were ready to start testing varieties from all the sites.

Quality evaluations 2000

The culmination of the harakeke evaluation trial was the gathering together of weavers to assess the quality of the different varieties. We decided it was most practical to carry out the evaluations at two locations, one to cover the North Island and the other the South Island sites. Cath Brown again kindly offered the hospitality of Ngāti Moki marae at Taumutu, and Kahu Te Kanawa arranged the use of the fibre arts building at UNITEC. The southern workshop took place just after Queen's Birthday weekend; the northern workshop was set for 2 weeks later, in the last week of June.

However, before leaf qualities could be assessed, the samples had to be gathered, labelled and measured (blade and butt lengths and widths). To ensure consistency in cutting and measuring, Sue carried out the sampling at all sites.

We chose six varieties for thorough sampling, three bushes of each, the same ones at each location – *Kōhunga, Māeneene, Ngaro, Paoa, Tapamangu* and *Tāpoto*. Sue also took leaves off one bush of the remaining six varieties – *Arawa, Ate, Hūhiroa, Oue, Parekoretawa* and *Paretaniwha*. Sue chose leaves from the healthiest and strongest fans, and labelling procedure followed that of the pilot study. The sites were also identified by number rather than placename.

Harvest time

The following is an account by Sue Scheele of the trip made to each South Island site to harvest the harakeke.

Tapamangu stood out as one of the few varieties to withstand the growing conditions at Kaiapoi Pā.

Oue at Omaka responded to irrigation and fertiliser.

Kaiapoi Pā – 31 May 2000

The first sampling day started very early. I woke at 4 am with a moth in my ear! It flapped about very vigorously and was obviously keen to get an important message across ... Greet the harakeke with respect… check you're sampling the right bush...make sure you cut those leaves at the right angle.. wrap them well in plastic to keep them fresh for the weavers... The moth delayed the start of my trip north (I needed a doctor's help to extract the poor creature), so it was midday before I reached Kaiapoi Pā.

The weather was sunny and warm and it was pleasant to wander in the old garden area of the Pā –Te Māra a Tuhoro Kaka. Sadly, of the few surviving plants scarcely any were of a useable size. I was able to cut and measure leaves of two bushes of *Tapamangu*, two of *Māeneene* (including a border plant), and one each of *Tāpoto* and *Arawa*.

Tapamangu continues to grow particularly strongly and the remaining bushes are healthy. It is good to know that such an excellent muka variety can perform well in the difficult growing conditions this *pā harakeke* has endured. *Māeneene* too is reasonably vigorous and a number of border plants continue to produce the multiple fans that are a distinguishing feature of this plant.

Omaka Marae – 1 June 2000

I woke to an overcast morning and before I finished my breakfast the rain started, getting heavier and heavier as the morning progressed. I felt almost as dismal as the weather, being mindful of the tikanga that harakeke should not be gathered in the rain. Around midday, the rain stopped and the strong Marlborough sun shone through the broken clouds. I decided to cut the leaves and went back to Omaka Marae. Many of the leaves were still damp, of course, but I had a supply of old towels with me and I dried each leaf as I cut it.

Last summer was too cool and wet for humans to enjoy, but the conditions were perfect for plant growth. Mild conditions throughout the autumn have ensured the flaxes at all sites have put on solid growth. At Omaka they also have irrigation in place and last spring Warwick applied NPK fertiliser to each plant. The result is a plantation of healthy bushes where I had no problems at all in cutting the required number of samples. The photo of *Oue* provides a good example of the difference that fertilised soil and frequent water can make to plant growth. Warwick had previously described the *Oue* plants as "especially stunted... [with] noticeable brown lesions on their leaves.". This can be seen on the old leaves, but the new season's growth has resulted in a healthy, vigorous plant.

Later that evening, I rang Cath Brown to discuss the dilemma I faced in cutting harakeke bushes in the rain. Cath agreed that the tikanga should be followed wherever possible. It's obviously not desirable to have bundles of wet flax in the working area and the harakeke leaves would be unpleasant to handle and difficult to work with. However, if the situation is such that the leaves need to be gathered at a certain

time and the weather is wet, then you do the best you can. Drying off each leaf with a towel, as I did, was the best alternative.

Taumutu – 2 June 2000

I went out to Taumutu early on Friday morning, anxious to collect the samples from both this site and Lincoln before forecast bad weather arrived. The plants have responded well to fertiliser and a wet summer, although there are still marked differences in the size of plants depending on where in the plot they are growing. The plants are mostly very healthy. For the purposes of the experiment, I sampled some bushes (a *Tāpoto,* and a *Māeneene),* which would normally have been disregarded by a weaver because the leaves are too small. One of the *Paoa* plants was too unthrifty to sample.

Lincoln – 2 June 2000

The Lincoln bushes are in lush condition. I scurried to collect the sample leaves before heavy rain arrived. With mature plants, some of the differences in form and growth pattern become more obvious. Finding the best 'number 4' leaves on *Māeneene*, for example, can be quite a challenge in a large bush – the multiplicity of fans, all overlapping each other, make it relatively hard work to isolate and cut the correct leaves.

Of interest among the bushes was one *Parekoretawa* where some fans had reverted to plain green rather than variegated. Out of interest, I took a sample of each leaf colour to see whether it would make any difference to the fibre extraction or quality.

Otākou Marae – 5 June 2000

The Saturday of Queen's Birthday weekend, I spent a long day measuring the widths and lengths of the sample leaves from the four sites. It was interesting to note the consistencies that appeared in some varieties, whatever the collection site. *Tāpoto*, for instance, tends to be the same width on the blade as on the butt. *Tapamangu* leaves are tightly folded at the junction of the blade and the butt.

On Sunday, I travelled with Geoff (Walls) and our son Finn to Dunedin. The weather was dismal but we could still enjoy the particular beauty of Otago Peninsula, especially out at the northern tip where the marae is located. Monday morning was overcast and drizzly, and it was excellent to have Geoff's help in gathering the samples. I cut the leaves and Geoff dried and labelled them. Again, lovely healthy plants – a few show signs of yellowing, but nothing extreme. The harakeke was well trimmed and weeded. The herbicide damage Warwick noted on his last visit was not evident apart, perhaps, from one *Ngaro* bush.

Quite a few bushes had flowered and Geoff cut off the kōrari and stacked them against the mānuka fence. Harakeke with kōrari were: *Oue, Hūhiroa* (all three bushes), *Ngaro, Parekoretawa, Ate, Kōhunga* and two bushes of *Māeneene*.

Te Wai Pounamu evaluation 6 – 8 June 2000

On Tuesday morning I drove out to Taumutu, the car laden with precious bundles of harakeke. Kahu Te Kanawa, Margaret Murray and Edna Pahewa had all arrived the day before and the working space was set up ready to go. It was lovely to see everybody again and I think we all felt excited and purposeful about the task before us. Perhaps a little daunted too. There were a lot of flax leaves! Would we get through them all in the allotted time? After a karakia, we got stuck in.

I handed round folders of recording sheets, revised a little according to our experience in the pilot study. The assessment criteria differed depending on whether the leaf was being evaluated for muka, raranga or piupiu

Extraction of muka and assessment for whatu – Kahu Te Kanawa

Kahu's task was to evaluate the muka qualities. A shearing comb was used to take standard strips from each leaf. Half of the

Geoff Walls bags leaf samples, Otākou.

Kahu extracting muka from leaf.

Pulling muka.

Extracted muka.

strips had an incision made with a mussel shell, the other half with a knife. Any differences shown up by using these different techniques was noted - in some varieties, for instance, the fibre is thin and will break under the pressure of the knife.

Kahu extracted the fibre using a shell. On a line marked 1 (not easy) to 5 (easily), she recorded how well the fibre stripped from the leaf, and how easily the para fell from the fibre. The thickness of the muka, how it separated out, and its suitability for whenu or aho were noted. The colour of both the para and the muka was recorded and whether the fibre was moist or dry to work with. Characteristics were circled from a list of words that could apply to muka – fine, thick, soft, strong, silky, pliable, weak, brittle, coarse, harsh, even.

Half of the muka was twisted into a cord (miro). Kahu noted how easily the strips divided before the ends were top and tailed.

Preparation and assessment of leaf strips for raranga – Margaret Murray

Margaret prepared even strips using the shearing comb. Strips were pulled from the take (butt) using if possible the pahuhu (or takiri) process. With one hand, the leaf strip is folded firmly against the take. Then the strip is pulled sharply away from the take, leaving a tuft of muka .

If the leaf was very hard, the whakapa method was used. With this technique, leaf strips are cut from the take with a knife and a short length of muka is scraped at the end.

The leaf strips were softened using the hapine process. In this process, the underside of the leaf is held against the back of a knife,

Kelly Smith putting tags on muka strips.

Cutting leaf into strips with shearing comb.

and the strip is pulled away. The process is repeated on the other side. This makes the leaf more flexible and stops the strips from rolling and shrinking as they dry.

Margaret made notes on the leaf moisture, smoothness, whether the leaf kept its form and its suitability for different items such as kete or whâriki. The strips were then labelled according to their position on the leaf blade: inner (next to the mid-rib); outer (the strip nearest the leaf margin); and middle.

An important consideration in choosing harakeke for raranga is the colour of the leaf when dried. This can vary depending on whether the leaf has been boiled or not, and on the time of year that the leaves are harvested. Because there are a range of variables to take into account, we didn't use this parameter for the purposes of this experiment. We will, however, note the colour of the dried leaf strips after a few months.

Margaret pulls the raranga strips.

Strip is pulled from the *take* (butt).

Softening the leaf (hapine).

Marking sections on the leaf.

Flicking para off the exposed sections.

Scraping para off the top of the leaf.

The top sections of muka are rolled together (miro).

Preparation of piupiu - Edna Pahewa

To prepare piupiu, Edna cut one strand from each side of the harakeke blade, judging the width by eye. The strips were laid on a marked board, and cuts made at regular intervals along the leaf (the smae intervals for every sample). Leaf sections were removed with a shell to expose the fibre. Note was taken of how easily the para cam away. This is important when making piupiu because para sticking to the fibre affects the uptake of the dye.

The tapered ends of the strands were stripped, fibre thickness recorded, and the muka strands joined using the miro process. The prepared strands were boiled for 7 minutes, then air dried. Once dry, each leaf strand rolls to create the familiar cylindrical shape of the piupiu.

Edna made note of the suitability of the leaf samples for different piupiu styles - short leaves are used for a man's piupiu, while longer blades are required for a woman's piupiu.

In all the process, the prepared samples and waste products were placed in seperate paper bags for drying and weighing.

Piupiu samples hanging to dry.

Recording the results.

Harvest time – North Island sites

Two weeks later, I set off around the North Island sites on the second harvesting trip.

Tanenuiarangi Inc – 20 June 2000

The harakeke is growing strong and healthily and is being used by the weaving group. There are scale on a few of the bushes, but the infestations are not severe. Two bushes, *Tapamangu* and *Ngaro*, had been well harvested, restricting the choice of leaves available for cutting. Both of these varieties have excellent muka. It was pleasing to see large, healthy bushes of *Oue,* which is an unthrifty bush at many other locations.

Otatara – 21 June 2000

The bushes here were looking generally better than when I saw them in early January, again showing the benefit of a wettish summer and autumn. All bushes of *Ngaro* show yellowing – two look poorly, but have new green growth and may be recovering. I cut sample leaves, but a weaver wouldn't normally have harvested from these bushes. Overall, there is definite variation depending on the situation of the plant, with bushes at the southern and eastern edges of the plot being less thrifty. The large bushes at the northern part of the plot have scale, though not too badly.

Again, I gathered 'reverted' leaves from variegated *Parekoretawa*, so that the weavers could assess if it made any difference to the properties of the variety.

Flaxes here have flowered – two bushes of *Paoa, Parekoretawa* and *Tāpoto*, and one bush each of *Kōhunga, Ate* and *Paretaniwha*.

I had my eye so firmly on the leaf samples and recording sheet that I nearly missed the most interesting aspect of the site. Preparing to take photographs, I suddenly realised that scattered in one part of the block were about 30 harakeke seedlings, some about 30 cm high. Some were associated with *Paoa* and *Kōhunga*, but it was not clear whether other varieties were involved. This is the first time that I have seen seedlings in a trial site. Normally there is too much competition from grass. At Otatara, there is good weed control and thick bark mulch surrounds the bushes. If the seedlings survive, it will be interesting to observe their growth pattern.

Ruamata Marae – 22 June 2000

At the Taumutu evaluation workshop, Edna said she would take her wananga group to Rotorua and weed around the flaxes before I came to harvest the samples. I was delighted to arrive at the Marae and find that Edna's group had indeed made a visit,

Large, healthy bush of *Oue* at Tanenuiarangi.

clearing away all the prickly blackberry tendrils from around the harakeke. This made my task much easier and certainly more pleasant.

The bushes are mostly of good size, though many are affected by leaf spot and mould. One of the *Paoa* at the lake end had the tops of the leaves chewed – perhaps by the wallaby that Warwick saw last year. A few bushes had flowered – two *Tāpoto*, one *Kōhunga* and one *Paoa*.

Seedling harakeke amongst plants at Otatara.

Ruamata trial site.

A heavily used *Paoa* at UNITEC with perched fans.

UNITEC – 23 June 2000

The UNITEC flaxes are the largest of all the sites. It was interesting to feel the weight and bulk of the bundle of sample leaves from this site compared to, say, the size of the bundles from Kaitaia, where the bushes are much smaller.

Many of the bushes, however, are suffering badly from leaf spot (rust), mould and scale. Conditions are ideal for the spread of such pests and diseases – a warm, humid climate and bushes that are now (because of their size) growing close together, thus restricting air movement. I noted that bushes that were well trimmed were less affected.

The spread of disease meant that it was difficult to get healthy, clean samples from some plants because the best leaves had already been harvested. Two of the bushes of *Ngaro* and *Tapamangu* were unable to be sampled because all fans had been harvested right back to the matua (awhi rito) leaves.

Some of the bushes had not been used, such as *Māeneene. Māeneene* has lovely fibre, and is a wonderful whāriki flax, but its growth habit of producing a great number of fans makes it difficult to get amongst, and sort out the right leaves to harvest. *Paoa* bushes had been overharvested, and the remaining fans were growing on rhizomes perched out of the ground. *Paoa* has a tendency to such 'perching'. It is such a heavy flowerer that the plant can exhaust itself easily. I suggested later to Kahu that remaining fans be replanted. It is a good idea to grow extra bushes of this harakeke. It is always very popular because the leaves dry to a gorgeous golden shade that look stunning in a kete.

Kahu came over while I was working away, and we took the bundles of flaxes that I had already measured over to her building on the other side of the campus. The building is designed for working with fibre, with large, comfortable working spaces, a specific place for boiling up dyes, areas to hang leaves or fibre-in-waiting, a kitchen – just perfect. And all around are items crafted by the students, lovingly displayed. An air of tranquillity pervades the whole building (possibly in part because the students were away!).

Kaitaia – 25 June 2000

Although the weather looked threatening, the rain held off while my cousin Adriane (who had joined me for the trip north) and I collected samples from the Kaitaia College site. The plants have responded very well to Warwick's fertiliser treatment and most are growing strongly, although overall the plants are smaller than elsewhere. The bushes are generally very healthy, though some (*Ngaro, Māeneene*) have a bit of leaf spot and mould, and one *Ate* had scale. Sampling was restricted on one bush each of *Tāpoto, Tapamangu* and *Paoa* because they only had one to three fans.

Two of the *Oue* that Warwick had recorded as being weak had died. The other had just one small fan and could not be sampled. One of the *Paretaniwha* was also very weak. Its two small fans had flowered. As at other sites, I cut off the kōrari of harakeke that had flowered. Two bushes each of *Parekoretawa*, *Kōhunga* and *Paretaniwha* had flowered, and one bush of *Tāpoto* and *Ate*.

Then it was time for the long drive back to Shelly Beach and an evening of more measuring. I completed this rather tedious task the next morning, sitting in the sun on the verandah with McD, a very old Labrador, gazing on at this strange activity.

Harvest at Kaitaia. Plants responded well to fertiliser.

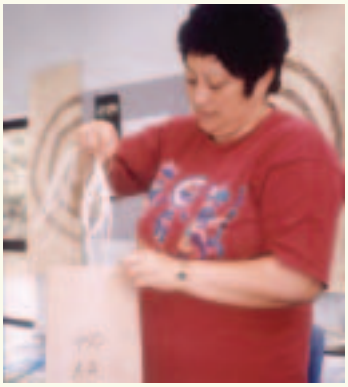
North Island sites evaluation 26 – 29 June 2000

After finishing the measurements, I drove to UNITEC arriving around midday. Kahu, Edna and Margaret were well underway with the bundles of harakeke that I had dropped off on Friday. Cath Brown was also working hard. She had brought a laptop and was working on both a weavers' newsletter and a report for Warwick and me covering the details of the techniques used. This time I was kept busy sorting and packing up all the samples and waste material to courier back to Warwick at Lincoln.

The evaluation methods used were the same as outlined above for the Taumutu workshop. By now, the weavers were deciding on their favourites of the 12 cultivars. Edna and Kahu particularly liked *Tapamangu, Kōhunga, Tāpoto, Māeneene, Arawa and Ngaro.* These varieties all have strong, fine muka which is easily stripped. *Parekoretawa*, the variegated harakeke, rated a mention too – it produced a good quantity of silky fibre. For raranga, Margaret liked *Māeneene, Kōhunga, Tapamangu* and *Paoa*. *Paoa* of course is not a muka flax, but really comes into its own when used for plaiting.

Cath Brown prepares a report on the evaluation.

The weavers evaluated a huge number of harakeke samples. Now back at Lincoln, we have further measurements to make on the dried material. Then the data must be collated and analysed, a complicated task that will take many months.



Kahu places muka sample in labelled bag.

Rene Orchiston and Sue Scheele at Lincoln.

Visit of Rene Orchiston to Lincoln

In October 2003 Rene was in Christchurch to be enrolled as an Associate of Honour in the Royal New Zealand Institute of Horticulture. Rene and her daughter Louise came out to Lincoln to see all the harakeke which Rene collected and carefully documented so many years ago. Her notes are in Harakeke. The Rene Orchiston Collection [Scheele and Walls (ed), 1994]. We were thrilled to be able to show them the well-tended and thriving collection.

The weaving team at UNITEC, June 2000.

Cath and Kahu in discussion.

Harakeke evaluation – the National New Zealand Flax Collection

In April 2001, Kahu, Margaret and Edna carried out an evaluation of all the varieties in the Orchiston Collection, along with a few others from the National New Zealand Flax Collection. The process was similar to that used for the experimental trial. Four leaves from each plant in the collection at Havelock North were sampled and compared with leaves from the collection at Lincoln.

Muka

Kahu did not find it easy to extract muka from most of the plants. On the whole, the para would not separate easily.

Canterbury had suffered a drought for the previous 4 months and this was evident in the lack of moisture when Kahu tried to extract the muka. The Lincoln bush of Diggeress's favourite, *Kōhunga*, did not even rate as a muka flax!

Some bushes, from both plantations, did stand out. *Makaweroa, Taumataua* and *Arawa* were all recorded as excellent. *Parekoretawa, Te Tatua* and *Whareongaonga* were also highly regarded, though their leaves are short, restricting their potential uses. *Ruapani, Ruahine, Taeore* and *Ngutunui* scored well too.

Most of the harakeke tested that was not part of the Orchiston Collection did not rate highly for muka, apart from Buckley Fyers' *Te Hoe*, and *Puhina*, one of Whero Bailey's harakeke. Edna brought down a fan of Emily's *Paretaniwha*, so we tried a leaf of that too. The muka extracted beautifully. The fine, silky fibres separated out well, making them very suitable for aho.

Raranga

Margaret scored most of the harakeke highly for raranga. The differences lie in what particular product each harakeke is best suited to. *Paoa, Turingawari, Mawaru* and *Ruhatairoa* were among those that rated highly for fine, plaited articles. *Paoa* is Margaret's favourite. A lot of the harakeke, such as *Tupurupuru* and *Takaiapu,* had long, strong leaves, making them suitable for backpacks. The all-rounder *Taeore* was regarded as excellent for making quality mats, as was the harakeke collected from Wairau Pā, near Blenheim. Margaret thought *Rangiwaho* and *Potaka* would be good to use in tukutuku panels, because their long fibres kept their form when scraped.

Again, one of the most important raranga features, the colour of the dried article, couldn't be assessed at this stage.

Piupiu

The good muka harakeke were also highly regarded for piupiu. *Taeore, Ngaro, Makaweroa, Taumataua, Matawai Taniwha* and *Ngutunui* had the length for women's piupiu, while *Takirikau, Motuonui, Ruapani* and *Ruahine* were suitable for men's piupiu. Other harakeke – such as *Tapamangu, Te Tatua* and *Whareongaonga* – were rated as excellent, but the leaves were only long enough to be used for children's garments. The *Kōhunga* from Havelock North rated well, though the para was a bit hard to get off from the butt end. The Lincoln *Kōhunga* did not rate so highly, because the para was hard to scrape. Similarly, *Tapamangu* from Havelock North was evaluated as an excellent flax for children's piupiu. At Lincoln, the para was much harder to get off.

A new flax industry?

Harakeke has long been used for shelterbelts and in riparian and wetland plantings, and today some councils are interested in growing areas of flax for flood control. Interest in other uses of harakeke is on the rise, and a number of researchers, iwi, councils, landowners and businesses are investigating its potential in a wide range of applications.

The NZ Flax Farmers Group, under the coordination of Liz McGruddy, Masterton, has a MAF Sustainable Farming Fund grant to explore a range of uses for on-farm plantings of harakeke. The aim is to enhance the on-farm environment, at the same time as sussing the practicalities of establishing a resource that can be used for regional enterprises based on flax products.

Among aspects being studied is flax's nutrient stripping capability. At three trial sites, AgResearch scientists are testing the nutrient concentration of harakeke (nitrogen and phosphorus, in particular), how nutrients vary from season to season, and the amount of biomass produced. Harakeke is mooted as a suitable plant to grow on riparian strips to absorb excess nitrogen from effluent, particularly on dairy farms. Dr Grant Douglas is particularly interested to find out how much nitrogen harakeke is capable of absorbing, and when the plants should be harvested to prevent the re-release of nitrogen from decaying leaves.

With the prospect of harakeke fibre or gel being used for speciality products, Liz is keen to find ways to deal with the waste by-products. One possibility is to convert the waste to animal feed. Certainly, we know that cattle love to eat flax – they do a great job in stripping the fibre! (see photo, page 21). Anecdotal evidence has suggested that calves thrive on flax, and Dr Annette Litherland, AgResearch, is evaluating the nutritional composition of harakeke leaves and testing whether the plant has anti-worming properties.

Off the farm, university researchers are investigating the performance of harakeke fibre as a component in earth wall construction, and its potential as a component in biopolymers.

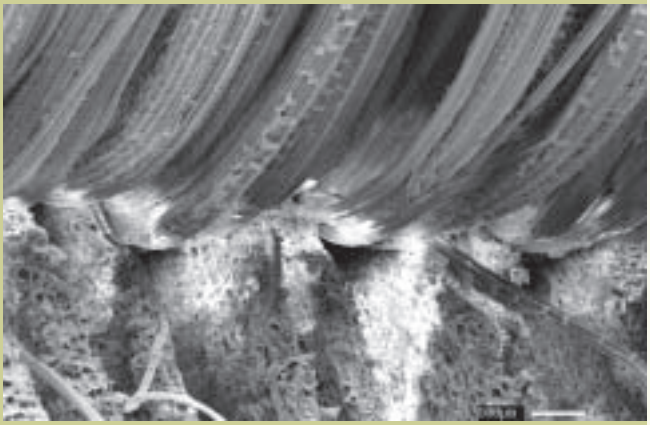
Weaver and harakeke conservator **Rangi te Kanawa (Muka Ltd)** and **scientists at Industrial Research (IRL)** are collaborating in new research on the fibre and gel of harakeke. They hope to find a suitable way to process the fibre to enable the production of high-quality textiles on a commercial basis. The gel too has potential as a cosmetic and health supplement.

Muka stripping

Marcus King of IRL has investigated extraction of muka fibre from harakeke by both the haro method and old industrial stripping machines. As a mechanical engineer who specialises in plant fibres he looked at the mechanics of the extraction processes that are applied to the leaves.

Marcus spent some interesting times with the microscope attempting to understand from an engineer's perspective what is actually happening to the fibres during the haro process. He collected leaves from 11 varieties grown in the Orchiston collection. Comparing the internal leaf structure of good muka varieties with ones that are not easy to extract fibre from show what it is that makes some varieties easier to extract fibre from than others. Electron microscopes give wonderful views of the leaf, and included here is a picture of the fibres coming out of a leaf during haro extraction. This leaf is Makaweroa, and the four bundles of fibres in the picture are coming out with almost no fibres left behind, and almost completely free of para. There are just a few parts of leaf cells attached to the fibres so very little further cleaning is required,

Grant Douglas, Liz McGruddy (by flax) and Annette Litherland prepare to excavate a flax bush.



Fibres being extracted from Makaweroa leaf.

Commercially processed harakeke fibre.

Stephen Tuawhare, IRL.

except to remove the leaf cuticle from the upper surface. Fibre extracted from non-muka varieties such as Paretaniwha looks very different, with large amounts of para attached.

Marcus visited the Foxton Flax Milling Museum to observe the European stripping machine that Gordon Burr looks after there. The speed that the stripping machines operate at is enviable, although the fibre is very different from that obtained by the haro method.

Pia harakeke

Many of us already use the gel that exudes from the base of harakeke leaves to heal cuts and sores on our hands (useful in the garden), and for applying to eczema. Stephen Tauwhare, harakeke scientist at IRL, is engaged on a project to examine the structure and physical properties of the gel.

Stephen has tested the pia harakeke from 48 varieties in the Orchiston Collection. He has found a wide range of variation in the gel's resistance to flow (viscosity), and also a lot of difference in gel yield between varieties. He's also found that pia harakeke shear thins at different rates according to variety. (A gel shear thins when it becomes easier to apply to something, like moisturiser on your skin). Stephen is currently investigating the impact of soil conditions and climate on gel yield and shear thinning properties.

Stephen has been busy visiting various whānau on marae to discuss the results of the research so far. He's also been gathering harakeke selections from around the country to compare with results based on the Orchiston varieties.

Stephen's work on gel, and also on fibre structure and properties (with Dr Roger Newman), contributes to our knowledge of harakeke. It is hoped the research will provide information to enable Māori to benefit from new technologies and participate in a renewed harakeke industry.

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New research on weaving plants

The committee of Te Roopu Raranga Whatu o Aotearoa tendered a successful funding application to FRST (Foundation for Research, Science and Technology) for further research on weaving plants. Funding has been granted for 4 years.

There are three parts to the programme:

1. The tikanga project

The first project is to promote amongst all weavers a deeper understanding of the tikanga and mātauranga pertaining to the kaitiakitanga of weaving plants.

Ranui Ngarimu says: "Over the next year or so, the project team - Te Aue Davis, Patricia Wallace, Kahu Te Kanawa and I - will be talking to experienced weavers about their harvesting and preparation practices, including spiritual aspects that are integral to our relationship with weaving materials. We'd love to hear from anyone who would like to share their knowledge, or who has suggestions on who should be contacted."

Ranui's contact details are:
Ph. 027 4382 625
Email: ranui.nga@xtra.co.nz

Pīngao, Ocean Beach, Hawkes Bay.

2. Distribution and habitat requirements of weaving plants

Secondly, weavers want to gain a better understanding of availability and access issues relating to weaving resources, and have subcontracted Manaaki Whenua scientists to help with this. Sue Scheele is project manager for this work. She says "We will systematically record where natural populations of weaving species are found throughout Aotearoa. We'll also collate information on the biology of each weaving plant, especially growing requirements and information on pests and diseases that affect the usefulness of the plants for weaving. Then we'll work with weavers to clarify the issues concerning availability and access in each rohe."

3. Studies on kiekie

Kiekie is argualbly the most important weaving resource after harakeke, so we will study it in more detail. People say that kiekie varies in leaf length (and therefore, usefulness) throughout Aotearoa. Sue says 'We will sample kiekie populations at several sites to show how much the plants vary, and indicate where further research is needed to assess if the variation is part of the genetic make-up of the plant, or is environmentally induced. At the same time, we will sample the kiekie for the nature and degree of insect pest and disease damage, to find out what environmental factors are contributing to the damage."

Te Roopu Raranga Whatu also want to study the long-term impact of different harvesting techniques on the sustainable use of kiekie. This study will provide an opportunity for a postgraduate Māori student to gain expertise in ecological studies while providing useful information for weavers.

Te Roopu Raranga Whatu o Aotearoa welcomes your comments and suggestions on this research.

The committee acknowledges with sincere thanks and aroha the input of Cath Brown into the research proposal.

The contact person for the weaving plant distribution and kiekie projects is:
Sue Scheele, Manaaki Whenua.
Email: scheeles@landcareresearch.co.nz
Phone: 03 325 6700.

Tikanga project planning group. Patricia Wallace, Sue Scheele, Cath Brown, Kahu Te Kanawa, Ranui Ngarimu.

Lydia Smith gathers kuta from Lake Ngata.

Kiekie, Westland.

Cover photos

Harakeke trial site, Taumutu; Harakeke evaluation - Kahu Te Kanawa, Margaret Murray, Edna Pahewa; Warwick Harris measures leaf width.

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