ARCHAEOLOGY IN NEW ZEALAND

AN EXPERIMENTAL KUMARA GARDEN AT ROBIN HOOD BAY NEAR PORT UNDERWOOD, MARLBOROUGH

Graham Harris[1], Mike Burtenshaw[1], Janet Davidson[2] and Foss Leach[2]

[1] The Open Polytechnic of New Zealand *He Wharekura-tini Kaihautu o Aotearoa*
[2] Museum of New Zealand *Te Papa Tongarewa*

Introduction

This project is associated with a FRST programme of research called "Bridge and Barrier" led by Foss Leach and Janet Davidson. The aim is to obtain data on yield for effort in producing a crop of a pre-European kumara (*Ipomoea batatas)* cultivar. This is part of a wider programme which aims to understand more about subsistence economics in the Cook Strait region in the pre-European period. Of special importance in this programme is to quantify the relative roles of protein, fat and carbohydrate foods in this region.

Several early authors including Colenso (1880), Walsh (1902) and Best (1925) recorded detailed observations of traditional Maori kumara culture. They agreed that kumara grew best on light sandy or gravelly soils and where suitable soils were unavailable, existing soils were modified by regular addition of fine gravel or sand. Recent authors have undertaken studies on the effects of traditional soil modification techniques on the growth and yield of kumara. Worrall (1993: 119-122) wrote that "Successful cultivation of a tropical crop in a temperate climate required careful selection of garden sites and modification of garden micro-climates". In a series of experiments she demonstrated that adding sand, gravel and charcoal to soils, either as a surface layer or incorporated into the surface layer, had the effect of raising soil temperatures and calculations of day-degree sums showed this was likely to produce significantly higher yields of kumara. Horn (1993) undertook a series of trials growing the cultivar[1] 'Rekamaroa' in Canterbury at what Leach (1989: 35) considered to be the southern limit for growing kumara. He found that the addition of sand as a surface mulch raised the soil temperature and increased yield, while incorporating sand into the soil reduced yield. He considered that this was due to "dilution of the (fertile) soil matrix by infertile sand".

Yen (1961) wrote about the sweet potato and its adaptation to New Zealand conditions by Maori and the same author (1963) provided descriptions of the pre-European cultivars still grown by Maori in the late 1950s. The names in most common usage of the pre-European cultivars he located and described were 'Rekamaroa', 'Taputini', 'Hutihuti' and 'Houhere'. A study undertaken by Harvey *et al.* (1997) compared these "ancient" cultivars (with the exception of 'Houhere' which was unavailable to them) with cultivars introduced in the 19th century and with several "modern" cultivars by using a technique of DNA fingerprinting by RAPD (Random Amplified Polymorphic DNA) analysis as a measure of taxonomic relationship. They found that 'Rekamaroa' and 'Hutihuti' are very closely related and 'Taputini' is quite distinct. All three "ancient" cultivars were quite distinct from "modern" kumara cultivars.

Savage and Bolitho (1993: 19) noted that numerous studies had been undertaken overseas on nutritional and chemical composition aspects of the sweet potato. They considered that overseas data may not be relevant in this country because growing conditions and the cultivars grown in New Zealand are different. It should be noted that "modern" kumara cultivars were used for their studies and their findings may not necessarily translate exactly to traditional cultivars.

There is no quantitative data available on the yields produced by pre-European kumara cultivars grown by traditional methods, although Walsh (1902: 12) wrote "...the kumara freely responded to care and attention in the most varied situations and yielded a large crop of an article at once palatable, wholesome and nutritious" while Colenso (1880: 11) recorded "In suitable seasons and soils, its yield was very plentiful" and he referred to "the immense quantity of this root which was raised annually by the old Maori".

Both authors referred to the avoidance of the use of manures to improve soil fertility by Maori, despite observing the obvious benefits of its use in the gardens of the early missionaries. Colenso (1880: 11) also wrote that Maori never watered their plants "...not even in times of great drought, with their plantations close to a river, when by doing so they might have saved their crops".

Observations about declining yields of traditional kumara crops grown by Maori were made in the early 1900s and a teacher at the native school at Whangape in the far north observed[2] "I may say that the kumaras grown here now seem to be deteriorating and I believe new seed will in a year or two be an absolute necessity". Another correspondent[3] to the Native Department in referring to kumara crops noted "they seem to run out of late years". It is possible that these declining yields were attributable to virus infection; however, virus infection of sweet potato was not formally recognised until the mid 1940s (J. Fletcher 2000 pers. comm.). The same informant noted that the only kumara plants showing virus symptoms in the *New Zealand Institute for Crop and Food Research* herbarium at Lincoln were those of the Yen collection which were returned from Tsukuba in Japan in 1988 (Parsons and Wihongi 1991: 15-18). While these plants were in quarantine, the Institute went to considerable effort using heat treatment and meristem culture procedures to free them of identifiable viruses before they were released. The original source of the kumara root tubers obtained by one of the authors in 1996 cannot be identified, however it is likely they originated from this source.

While the literature provides details of many aspects of traditional kumara culture, it appears that no studies have been undertaken to provide quantitative data on yield for effort - data that is essential to gain an understanding of prehistoric human nutrition and the production of non-protein energy sources. Some clues as to the work required in maintaining kumara crops were however provided by Walsh (1902: 16) who referred to "the careful neatness in clearing out the weeds" and noted that the planting of the crop was a communal effort and was always completed in a single day. He reported:

> The work of cleaning the crop was a comparatively light one in the old days, as the host of troublesome weeds that have accompanied European cultivation had not then made their appearance. One weeding was considered sufficient, and it was done in the dry weather by a party made *tapu* for the occasion, and armed with small wooden spades shaped something like a short paddle.

Method

The aim of this study was to calculate the yield in return for human effort in producing a crop of a traditional kumara. The cultivar grown was 'Taputini' which was obtained from Northland in 1996. This cultivar is characterised by its deeply lobed leaves and compact, bushy habit of growth. Morphological characteristics of the plants and their growth habit were carefully compared with the descriptions provided by Yen (1963: 37) to ensure authenticity. Figure 1 shows root tubers and leaves of a 'Taputini' plant.

Figure 1. The root tubers and leaves of the pre-historic kumara cultivar 'Taputini'.

It should be noted that the kumara and in particular the traditional cultivars are the subject of a Treaty of Waitangi claim (Wai 262) and are regarded by Maori as a cultural symbol in addition to their significance as a traditional food crop. Prior to setting up the garden plot, all iwi authorities in the area where the experimental garden plot was to be established, including those holding *manawhenua,* were contacted for discussions on the project. Te Atiawa, Ngati Rarua and Rangitane were visited in person by all the authors, and Ngati Toa were contacted by phone and letter. There was approval from all quarters for the research work. After harvesting the plants and collecting data, most of the crop was distributed to iwi representatives. Some root tubers were kept for establishment of the 2000/2001 crops.

A garden was established at Robin Hood Bay in Marlborough, an area which Leach (1976) considered to be climatically marginal for kumara production. The garden was located in the vicinity of a known prehistoric Maori garden site (Fig. 2.). A 5 by 5 metre (25 square metre) plot back from the archaeological remains of the stone rows was fenced and cleared from pasture. A 1 metre high fence to which 30 mm mesh wire netting was attached was constructed around the garden to exclude sheep and rabbits. Wind-break cloth was placed over the wire netting to provide protection for the plants.

The soil type was a silty clay loam with a good crumb structure, having been under pasture for a number of years. Figure 3 shows an analysis of a soil sample taken from the site prior to planting the crop. The data indicates low nutrient status levels for most elements. Of particular significance is the low level of potassium which Bouwkamp (1942: 17) considered to be the key element in the fertiliser programme of sweet potato. Lewthwaite (1999: 22) noted that corrections of mild deficiencies of potassium can result in large increases in kumara yield.

After cultivation, 38 mounds (*puke*) 40 cm in diameter and 30 cm high were formed in a quincunx pattern (Fig. 4). In each *puke* two seed root tubers were planted, one on the north side and one on the south side, making a total of 76 seed root tubers planted. The reasons for planting two root tubers in each *puke* was to ensure that at least one sprouted and grew and because Best (1925: 118) recorded that this was a common traditional practice. Two visits were made to inspect and weed the garden and the crop was harvested and the yields recorded on April 13, 2000, after 168 growing days.

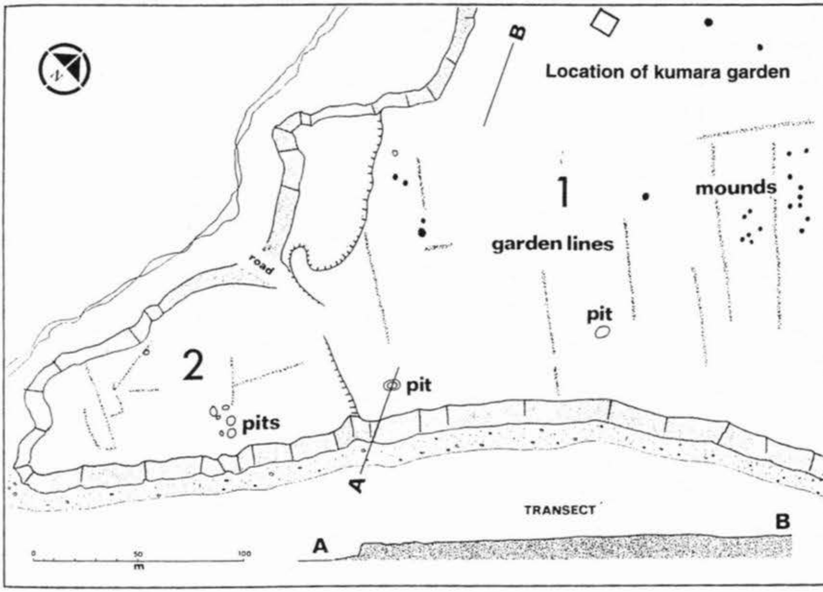

Fig 2. Location of the experimental garden site at Robin Hood Bay in relation to pre-historic garden sites. Adapted from Brailsford 1981.

Sample Name: Soil				Sample Type: SOIL General, Outdoor S10		
ANALYSIS		LEVEL FOUND	NORMAL RANGE	NUTRIENT STATUS LOW	MEDIUM	HIGH
pH		5.0	5.8 – 6.5			
Olsen P	(ug/ml)	12	20 – 30			
Potassium	(me/100g)	.45	0.50 – 0.80			
Calcium	(me/100g)	6.1	6.0 – 12.0			
Magnesium	(me/100g)	1.40	1.00 – 3.00			
Sodium	(me/100g)	.11	0.10 – 0.30			
CEC	(me/100g)	18.2	12.0 – 25.0			
Base Saturation	(%)	44	50 – 85			
Volume Weight	(g/ml)	.94	0.60 – 1.00			
K/Mg Ratio		0.3	0.3 – 1.0			
Base Saturation Data				%K 2.5 %Ca 34	%Mg 7.7 %Na 0.6	
MAF Cation Units				K 9 Ca 7	Mg 30 Na 5	

Figure 3. Soil analysis results for the garden site.

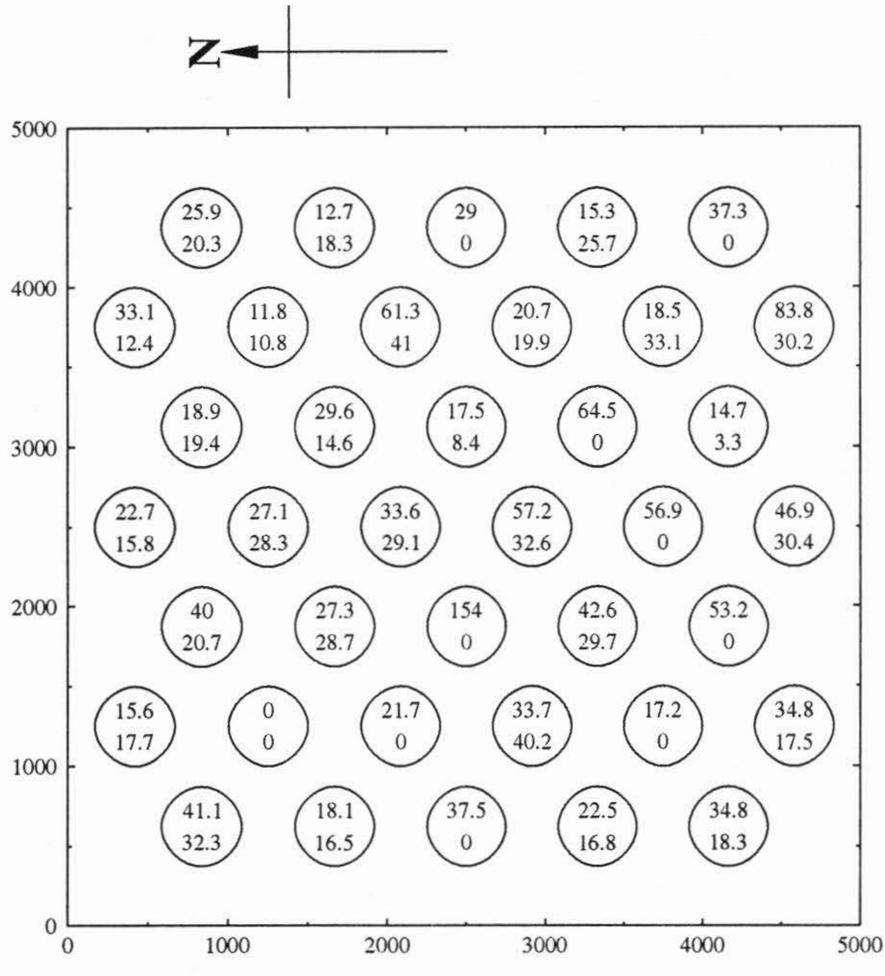

Fig. 4. Layout of kumara plants and yields per plant.

Results

A total of 15 person-hours was required to grow and maintain the crop on the 25 square metre plot from cultivation to harvest (Table 1).

Table 1: Work hours for 25 square metre kumara garden (Robin Hood Bay 1999/2000)

Date	Task	No of people x hrs	Total hours/task
27/10/99	Digging over	2 x 1.5	3
28/10/99	Secondary cultivation	2 x 0.5	1
28/10/99	Forming mounds	2 x 1.0	2
28/10/99	Planting "seed"	2 x 0.5	1
16/12/99	Weeding and cultivation	2 x 0.5	1
25/02/00	Weeding and cultivation	2 x 1.0	2
13/04/00	Harvesting	2 x 2.5	5
Total			15 work hours

The total yield from the 25m^2 garden was 29,432 kilograms which is equivalent to 11.8 tonnes per hectare. This can be compared with the yield of recent kumara crops growing modern cultivars. Coleman (1978: 6) noted that the average yield for kumara in 1972 was 15.75 tonnes per hectare. In the experimental garden there was a significant difference in yield between plants growing on the north side and south side of the mounds with a total of 19,758gm harvested from plants with a northerly aspect on the mounds and 9,838 gm from those on the south side. The yield from individual plants varied greatly, and ranged from 2g to 1858g. A similar variation in yield was observed by two of the authors from crops of 'Taputini' grown in 1997 and 1998 in the Hutt Valley and in Martinborough. The low potassium levels in the soil as indicated by the soil analysis (Fig. 3.) was not reflected by the typical symptoms of potassium deficiency (interveinal chlorosis) as described by Bouwkamp (1942: 12).

Discussion

This was a pilot project designed to gain a first impression only of the yield for effort in producing a kumara crop. Many traditional cultivation practices were deliberately avoided, for example modern steel spades, forks and hoes were used for cultivation and harvesting rather than the traditional wooden implements. We used modern wind-break cloth rather than the traditional manuka brush wind-break described by Walsh (1902: 20). This project is not concerned with rediscovering *matauranga,* but in gaining a better understanding of the minimum hand work required for kumara gardening, and comparing this with the yield obtained. We fully appreciate that by using traditional methods, the person-hours might be increased, but we do not think they would be decreased from the work carried out by ourselves. We noted that the root tubers were very brittle and broke easily which made harvesting a delicate operation which took more time than lifting a crop such as potatoes.

Fig. 5. 'Taputini' kumara plants in the experimental garden. Note the compact growth habit.

We also appreciate that the hours of work need to be adjusted upwards to take into account other work required such as clearing the land of vegetation and rocks, digging storage pits and selecting and carrying kumara to storage pits. On the other hand, aggressive and vigorous introduced weeds competed strongly with the kumara plants and required very careful removal to ensure the crop plants were not disturbed. The weeds present, all of which are introduced species, were black nightshade (*Solanum nigrum*); catsear (*Hypochaeris radicata*); woolly mullein (*Verbascum thapsus*); dock (*Rumex obtusifolius*); puha/sow thistle (*Sonchus oleraceus*); yarrow (*Achillea millefolium*); narrow-leaved plantain (*Plantago lanceolata*); Scotch thistle (*Circium vulgare*); red clover (*Trifolium repens*); white clover *(T. pratense*); sheep's sorrel (*Rumex acetosella*) and pennyroyal (*Mentha pulegium*).

Three kumara samples were prepared for proximate analysis at the *Institute of Food, Nutrition and Human Health*, Massey University. These were AK 1002 and AK 1003, one large root tuber each, and AK 1004 consisting of five small root tubers. The results are shown in Table 2.

Table 2: Nutritive values of kumara/sweet potato.

	Protein*	**Fat***	**Carbohydrate***	**Gross energy***
AK 1002	1.26 g	0.22 g	17.55 g	93.1 kcal
AK 1003	0.94	0.20	-	90.4
AK 1004	1.39	0.20	-	105.9
means	1.20	0.21	17.55	96.5
kumara A [1]	0.76	0.16	30.82	128
kumara B [2]	0.90	0.00	-	150.0
kumara C [2]	1.70	0.30	28.50	150.0
USND [3]	1.65	0.30	24.28	105.0

* *All values are given per 100g*

[1] Murai *et al.* (1958)

[2] Massal and Barrau (1956)

[3] US Nutrition Database, Dept Agriculture

It is not always clear in published figures how the analyses are carried out, or the precise meaning of reported figures. We assume the energy values reported are "gross energy per wet weight" which is what our figures are. Our carbohydrate values are hot water soluble carbohydrates (HWSC) whereas the USND value is calculated by difference from other components.

The HWSC value will include most of the starch, all of the mono- and oligo-saccharides, and some of the pectin (hemicellulose). The HWSC is acid hydrolysed to produce mono-saccharides and the mono-saccharide content is estimated as reducing sugars. Not all sugars are reducing sugars, so this might be a slight underestimate.

It is interesting to note that the 'Taputini' gross energy value appears to be somewhat lower than the other cited values. This appears to be due to the substantially lower value for carbohydrate in these samples, but not knowing how the other values were arrived at makes it difficult to assess the significance of this. We will be carrying out parallel analysis of some other modern cultivars in due course using strictly comparable methods to see how 'Taputini' compares as a source of food.

It may be noted that the values for the five small root tubers combined is slightly higher than for the two larger tubers. This is mainly due to the fact that the larger tubers had greater moisture contents (76.7% and 77.3%) compared with the small root tubers (73.6%). It would therefore be interesting to assess the food energy gain per plant during the root tuber maturation process in the growing season. There may be an optimum harvesting time, in terms of energy yield per plant, before the tubers reach their maximum size and maximum water content.

The yield in this experimental kumara garden of 11.8 tonne per hectare is equivalent to 11.387×10^6 kcal/ha for such a crop.

Planned Future Work

Crops will continue to be planted for some years at the Robin Hood Bay garden to assess the effects of soil exhaustion over time. Detailed soil temperature and climate measurements will be taken. A 'Taputini' crop will be grown at Palliser Bay to compare results from the north side of Cook Strait which has different environmental and soil conditions. This garden will also be located in the vicinity of a prehistoric garden site where kumara were grown. The cultivars 'Rekamaroa' and 'Hutihuti' will also be grown in future trials to compare yields and general plant performance on sites which can be marginal for kumara production.

Acknowledgements

Thanks are due to Richard Gill on whose property the experimental garden was located, for allowing us access, and to the following iwi authorities for their support and encouragement: Te Atiawa, Ngati Rarua, Ngati Toa and Rangitane.

End notes

[1] In this paper, the *International code of nomenclature for cultivated plants* (Brickell 1980) is followed, in providing the Maori named cultivars with single quotes and leading upper case letter.

[2] MA21/4 National Archives, Wellington.

[3] MA21/8 National Archives, Wellington

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